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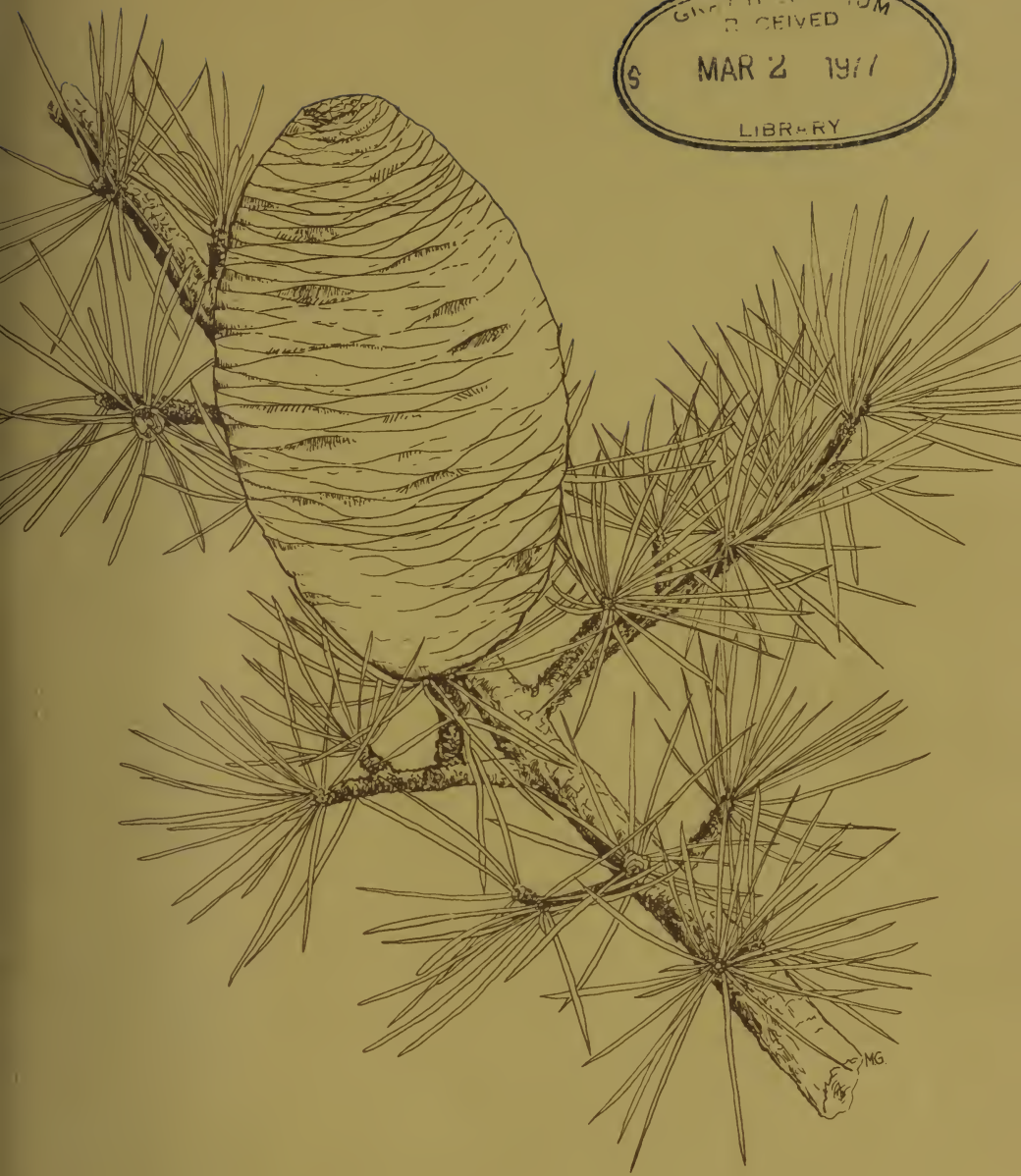

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Cover: Cedrus libani *var.* stenocoma. *Drawing: M. Givens.*

Propagation Manual of Selected Gymnosperms

by Alfred J. Fordham and Leslie J. Spraker *

FOREWORD

Although this manual is designed for the advanced amateur, the authors sincerely hope that professional propagators will find information of interest to them within its pages.

With the amateur in mind, the manual is prefaced by a discussion of common propagating techniques and appended by a glossary of propagating terminology. It is hoped that readers will refer to these whenever questions arise as they use the manual.

The genera treated are arranged alphabetically. Recommendations for propagation are general for the genus, unless otherwise specified. In some cases, experience with propagation of a genus has been limited at the Arnold Arboretum because the species are not hardy in the Boston area. Efforts to gather propagating information on these plants were frequently disappointing, and contributions from readers will be welcomed. Brief bibliographies follow the propagating information on each genus. These by no means are complete, but may suggest directions for further research on the part of both amateurs and professionals.

The nomenclature used follows that of Den Ouden and Boom.

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The manuscript was submitted by Miss Spraker to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Science in Ornamental Horticulture.

Taxonomist at Longwood Gardens, Gary L. Koller, Supervisor of the Living Collections at the Arnold Arboretum, Dr. Richard W. Lighty, Coordinator of the Longwood Program at the University of Delaware, Dr. Russell J. Seibert, Director of Longwood Gardens, Dr. Stephen A. Spongberg, Assistant Curator at the Arnold Arboretum, Dr. Richard Warren, Arnold Arboretum volunteer, and Dr. Richard E. Weaver, Jr., Horticultural Taxonomist at the Arnold Arboretum.

The bibliography was painstakingly verified by Mrs. Ida H. Burch, Curatorial Assistant at the Arnold Arboretum; Ms. Nancy LeMay patiently typed and retyped the manuscript. The sketches were prepared by Monroe M. Givens, graphic designer at the University of Delaware.

We also are grateful to D. M. Henderson, Royal Botanic Gardens, Edinburgh, for information quoted as D.M.H. in the text.

Male and female cones of Abies koreana. *Fertilized cones will mature in autumn of their first year. Photo: H. Howard.*

INTRODUCTION

Botanists divide seed-bearing plants into two groups — angiosperms and gymnosperms.

Angiosperms bear true flowers and fruits. The male reproductive structure is the stamen. The female reproductive structure consists of one or more carpels. The usually enlarged base of the carpel, termed the ovary, contains ovules which, when fertilized, develop into seeds. As these mature, the ovary also undergoes structural changes and, at maturity, is termed the fruit. The seeds are enclosed within the fruit or ripe ovary, and are called angiosperms or enclosed seeds.

Gymnosperms do not bear flowers or fruit, though their reproductive structures can be roughly equated to those of angiosperms. Pollen is borne on modified structures called microsporophylls. These occur in small, cone-like clusters on branches and are often incorrectly referred to as male "flowers." There is no real carpel or ovary in the female reproductive structure of the gymnosperms. Instead, the ovules usually are borne either singly or in pairs on the surface of structures called megasporophylls. As a result, the ovules are exposed, or "naked," and are called gymnosperms or naked seeds. After fertilization, the ovules develop into seeds and the megasporophylls also undergo structural changes. The familiar pine cone is an aggregation of megasporophylls, while the fleshy red structure that partially encloses the seed of *Taxus* is a single megasporophyll. Since gymnosperms have no carpels, their reproductive structures technically cannot be called "flowers" or, when ripened, "fruit," and in this manual they will be called "cones."

Gymnosperms may be propagated in two ways — by seedling (sexual) or vegetative (asexual) reproduction. Seedling reproduction is generally more economical, but it allows for genetic variation among the propagants and usually requires more time to develop usable plants. However, seeds and seedlings are uniform enough in size that they can be handled by mass production techniques. This is of importance to growers producing large numbers of plants.

Vegetative propagation eliminates the problem of genetic variation since propagants identical to the parent plant, that is, maintaining their unique characteristics, are produced.

SEXUAL PROPAGATION

Limitations of Seedling Propagation

Genetic Variation of Seedlings

The horticultural characteristics of a plant are determined by its genetic make-up. They can be altered by recombination or mutation of the genes. Variation among cultivars of some plants such as false-

cypress (*Chamaecyparis*) seems to be derived from both recombination and mutation; that of others, like hemlock (*Tsuga canadensis*), is largely derived from genetic recombination.

Each gene affects the expression of some characteristic of the plant. In many cases, the effect of the gene is hidden for many generations until recombination allows it to be expressed. Recombination occurs only in the sex cells, prior to fertilization of the ovule with pollen. Therefore, variation due to recombination occurs only among seedlings.

Mutation, on the other hand, may alter horticultural characteristics at any time during the life of a plant. Such mutation affects the nature of a gene, so that its expression produces a different characteristic. If mutation occurs at an early stage in plant growth, the entire plant may be affected. More often only a single branch, or even a small part of a leaf, is modified. Generally, mutation affects only one characteristic while recombination has manifold effects.

In nature, genetic variation among seedlings can be advantageous, since it allows a particular species to adapt to changes in the environment. A tall, rapid-growing pine may have a competitive advantage, surviving in a crowded woodland situation where competition for light is intense, while a lower, slow-growing plant may not survive. Seedling variability is also a key factor in the development of new cultivars, and many superior horticultural taxa have arisen this way.

Seedlings of Pinus strobus (*Eastern white pine*), *show similarity of size. They germinated in unison after two months of cold stratification at 40° F. Photo: P. Chvany.*

However, in cultivation variation may reduce the value of a plant, depending on its intended use. Uniformity of characteristics is especially important for plants used in landscaping. In a hedge or a row of trees, for example, similarity of form, color, texture, and growth rate may be essential.

Sex of Seedlings

In some gymnosperms, male and female cones are produced on different plants. Frequently, one sex is preferred for cultivation. For instance, since large female ginkgos (*Ginkgo biloba*) produce prodigious quantities of foul-smelling "fruits," * male plants are usually grown. Sex of plants propagated by seed cannot be determined until the plant is mature enough to develop reproductive structures. Most gymnosperms do not mature for many years, by which time they are large and occupy prominent positions in the landscape. (The authors know of a specific instance where a ginkgo produced reproductive structures for the first time after twenty-four years.) Therefore, when young plants of a particular sex are required, they must be propagated asexually from clones of a known sex.

Time Required to Produce Plants

Sexual propagation of most gymnosperms is slower than asexual propagation. The seeds of some species require extended periods of pretreatment to break dormancies and seedlings require more time to develop into mature plants than do vegetative propagants. Umbrella-pine (*Sciadopitys verticillata*) seedlings, for example, usually produce only cotyledons, or seed leaves, the first year and several true leaves the second. The whorl of leaves for which the plant receives its name appears during the third year. At this time the seedling has attained a size comparable to that of a cutting taken for propagation.

Advantages of Seedling Propagation

The primary advantage of seedling production is that large numbers of plants can be reproduced easily and inexpensively. This is particularly important for those genera used extensively in reforestation, development of shelter belts, and Christmas tree farming.

Most gymnosperm seed can be stored for at least short periods. The seeds of some "fire" pines (*Pinus attenuata*, *P. contorta*, *P. muricata*, *P. pungens*, and *P. radiata*) remain viable as long as twenty-five years or more in cones on the tree; seeds of *P. contorta* in closed cones have been reported viable after eighty years.

Relatively little storage space is needed for seed of gymnosperms.

Large quantities of seed can be shipped easily and inexpensively to any location in the world, while vegetative propagating material requires special handling and packaging techniques. Many states

* See page 1.

and countries have quarantine barriers against the latter, but will allow seeds to cross their borders since they are less apt to harbor disease organisms and insect pests.

Sources of Seed

After obtaining permission from landowners, small lots of many types of gymnosperm seed may be collected from individual specimens along roadsides and in natural woods. When possible, parent plants should be evaluated for form and other characteristics, and seed taken only from those most desirable. Some botanic gardens and arboreta make seed of unusual plant taxa available upon request.

Large quantities of seed needed by commercial seedsmen and foresters are ideally collected from designated seed production areas where trees have been developed and evaluated for special characteristics. Foresters throughout the world have long recognized the need for selecting superior seed plants. Evaluation of seed trees is especially important for producers of Christmas trees, lumber and paper products, since their trees must be standard for certain desirable characteristics such as size, color, shape, and rate of growth.

In some cases, seed can be purchased from commercial dealers who specialize in controlled storage, handling, and sales. These dealers should specify the place and year of origin, and indicate the percentage of foreign matter.

Where possible, seed from plants of known hardiness should be used, since seed lots vary widely in this respect, depending upon the locality of origin. In most species, distinct strains (termed geographic races) varying in hardiness have evolved. For example, seed of Douglas-fir (*Pseudotsuga menzesii*), collected in the Rocky Mountains, tends to be hardier in the Boston area than seed of the same species collected along the West Coast.

Harvesting of Seed

Harvesting dates depend on the natural agents of dispersal and seed ripeness. Ideally, seed should be collected as soon as it is mature, but before natural agents remove it from the tree.

Natural Dispersal

The natural agents responsible for distributing gymnosperm seed are wind, water, birds and animals. Of these, wind is the most important. Most gymnosperms produce light, winged seeds that are whipped from their opening or shattering cones by the wind and carried varying distances, depending on wind velocity and plant location. These seeds also float in water and may be carried far away from the parent plant if they happen to fall into a river or stream. Cones must be collected immediately prior to opening to assure maturity and prevent loss of seeds.

Taxus *reproductive structures comprised of single seed surrounded by a fleshy cone scale open at the apex. They must be collected before they are taken by birds and animals. Photo: H. Howard.*

A few gymnosperms, including yew (*Taxus*), and juniper (*Juniperus*), produce fleshy, succulent cone scales that are eaten by birds and animals. The pulp furnishes food while the hard-coated seeds pass through the vectors' digestive tracts and are scattered about the countryside in their droppings. Migratory birds may carry seeds some distance from their point of origin. Seeds in fleshy coatings that are attractive to wildlife must be collected just prior to the final color change. At this stage, the seeds will have developed enough to be viable, but the immature cones will not appeal to their natural consumers.

Seed Ripeness

In general, seed is ripe when the surrounding structure begins to develop characteristics that lead to natural dispersal. Fleshy cone scales change color and become palatable, attracting vectors. Dry cone scales begin to separate for release of seeds to the wind. No single characteristic can be used to determine the ripeness of all seed. Color and dryness of the cone scales may be used as an indicator of maturity for some species. In others, the texture, color, moisture content, and hardness of the seed itself may suggest ripeness. It is important to know the characteristics that indicate ripened seed for a particular species.

Cones of Pinus strobus *open and release seeds to wind dispersal during late summer of their second year. Photo: H. Howard.*

On a single tree, most gymnosperm seed ripens uniformly, but neighboring trees of the same species may differ, making collection of large seed lots difficult.

Harvesting Techniques

Fallen seed can be collected from the ground if one is certain of its identity. Standing trees present more of a problem, since fruit is frequently borne high on the branches. Often, seed can be shaken free by agitating the tree limbs. Cone hooks with curved metal blades attached to a long light pole may be used to cut cones from high places. Pole shears — two cutting blades mounted on a pole and operated with a line or wire — also may be used. Cones that shatter upon ripening, such as those of the true cedars (*Cedrus*), firs (*Abies*), and golden larch (*Pseudolarix amabilis*), must be hand-collected. Before collecting seed from any one source, a sample should be checked for sound contents.

Cleaning of Fleshy Cones

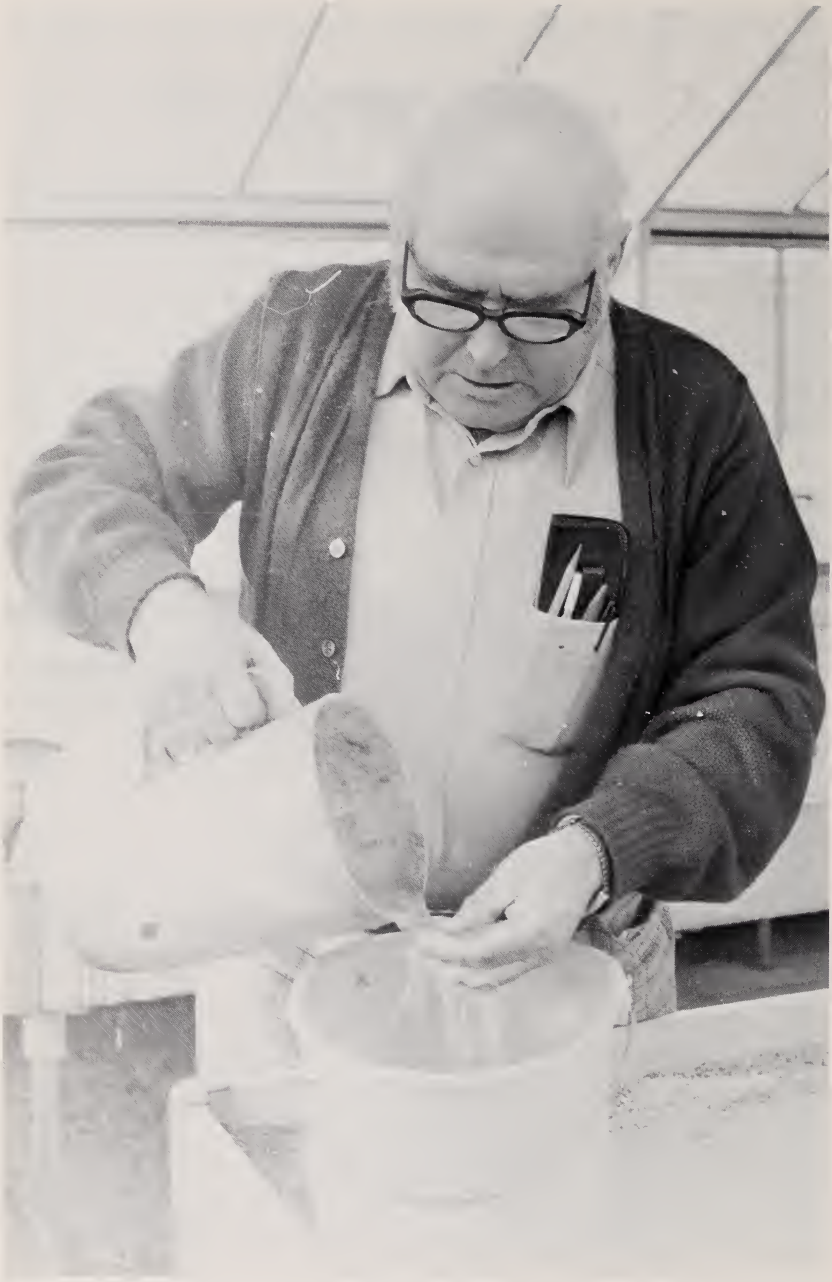
Because of decay organisms and limitations of storage space, seed should be separated from the fleshy cones as soon as possible after collection. The pulp surrounding most seeds contains inhibitors that prevent premature germination of the seed while it is still attached to the parent tree. This pulp must be removed to permit germination.

In many cases, moist pulp of fleshy cones starts to decompose a few hours after collection. If not controlled, this may lead to seed spoilage and loss of viability, but it is an important first step in the separation of viable seeds. The pulp decomposes into a soft mass that is easily separated from the seeds by maceration and flotation techniques. Disintegration may be hastened by placing the cones in a container and adding a little water. The material should not be allowed to remain in the containers longer than necessary to break down the pulp, since decomposition may cause heat build-up or production of harmful chemicals.

Maceration and Flotation

Seeds and softened pulp may be separated by macerating the mixture gently but thoroughly and placing it in a container of water so that heavy, sound seeds sink to the bottom while the lighter pulp and void seeds float. The pulp mixture and water are then poured off, leaving only clean, sound seeds in the vessel. Tall, narrow containers are especially efficient for flotation as the tall column of water allows wide separation between floating pulp and sound seeds. Two or three washings may be necessary.

Small quantities of fleshy cones may be hand macerated; mess and inconvenience can be avoided by kneading them in a disposable plastic bag. Large quantities are processed in specially constructed macerating machines.



Seeds and macerated pulp are separated by floatation. Sound seeds sink while pulp and void seeds float and can be poured away. Tall narrow vessel allows wide separation of pulp and seeds. Photo: P. Chvany.

Small amounts of fleshy pulp can be separated from seeds by hand-kneading the mass in a disposable plastic bag. Photo: P. Chvany.

At the Arnold Arboretum, a food blender is used to clean small quantities. The blender has been modified by removing its blades since they chop up the seeds. A small square of reinforced rubber, taken from the center of a worn truck tire, has been fastened to the cutter head, concave side up. This rubber square beats the cones effectively without injuring the seeds.

Cleaning of Dry Cones

Cones produced by most gymnosperms must be allowed to dry so that the scales separate and the seeds can be extracted. Air drying of cones spread out in shallow layers takes from one to three weeks, depending on the species, stage of maturity, and atmospheric conditions. It is best done in a location where animals, rain, and wind will not be disruptive. Good ventilation and periodic turning of cones will insure even drying.

Cones of the fire pines open only at high temperatures and are dried in heated kilns by commercial processors. Small quantities of

many gymnosperm cones can be opened by placing them in a closed paper bag on a home radiator. Cones of other species requiring greater heat can be dried in the kitchen oven at temperatures not exceeding 130°F.

Some cones (i.e. *Cedrus*, *Abies*, etc.) may be opened by soaking them in water, after which they crumble apart. Wetted cones that fail to open can be frozen out-of-doors in winter, or in a freezing unit. Ice crystals form and force the scales apart.

After opening, cones must be shaken to remove the seeds. Cones and seeds are separated by shaking them in a screen with mesh small enough to retain the cones or scales but large enough to allow passage of the seeds. Commercial seedsmen tumble large quantities of cones in revolving wire cages above containers that catch the seeds.

Fanning and Winnowing

Cones of the firs, true cedars, and golden larch are composed of scales and seeds surrounding a central woody axis. When dry, these shatter and the seeds must be separated from the scales. In some species there is little difference in size between the winged seeds and the scales, and so screening does not work. However, the winged seeds are much lighter and small numbers can be separated by gently blowing the material as it is passed slowly from hand to hand. The scales are retained in the hand while the seeds are carried away to a nearby surface where they can be gathered.

Large numbers of seeds and scales can be separated by placing the material in a screen and bouncing it in the air current of an electric fan. The heavier scales remain in the screen while the seeds are blown a short distance away, where they can be collected later. Some experimentation is necessary to determine how close the screen should be placed to the fan.

Dewinging

Seeds of a number of gymnosperm species are fragile and easily damaged by dewinging. In commercial practice, the wings are removed with specialized equipment that reduces the chance of injury. If small quantities are to be processed, and the seeds are not easily damaged, they can be dewinged by rubbing them between the hands; if the seeds are fragile, they can be sown satisfactorily with wings remaining.

Storage

Many gymnosperms bear seeds sporadically, the intervals between crops varying with climatic conditions and species. Seed crop quantity also fluctuates, with trees producing more seed in some years than in others. Growers who use seed annually must store it from year to year to assure its availability.

Screens of various mesh size are used to separate seeds from cones, cone scales, or extraneous matter. Photo: P. Chvany.

Optimum storage time varies greatly with genus, species, and seed lot. Some seeds can be held for years with little difficulty, while others normally lose viability within a few months. Germinative capacity following storage also is determined by seed viability at harvest and method of storage. The most favorable conditions for storage of any seed species are those that slow natural desiccation and reduce the rate of respiration and other metabolic processes without injuring the embryo. Moisture content and storage temperature appear to be the most important exterior influences on seed longevity.

Moisture Content

Most gymnosperm seed endures long periods of storage best when stored dry. In many cases, the moisture content of seed is affected by the degree of saturation of the immediate atmosphere. Seeds absorb or give up moisture until they are in equilibrium with the surrounding air. Frequently, fluctuations in moisture content caused by variation in the relative humidity are detrimental to seeds and reduce their longevity, but the extent to which relative humidity affects seeds in storage depends upon the species. Ideal storage conditions should maintain atmospheric moisture at levels which insure constant low moisture content of seeds.

In temperate climates, a suitably low moisture content can be achieved by air-drying the seeds. It then can be maintained by storing them in a sealed, vapor-proof container. Polyethylene bags are suitable since they seal tightly and easily, are moisture-proof and allow some exchange of gases.

For short periods, seeds of those species that require cold treatment before germination are best held at high moisture content. They can be mixed with a dampened medium such as sand and peatmoss, and placed in a sealed, vapor-proof container held at about 40° F.

Temperature

As storage temperature drops, viability of gymnosperm seed is prolonged. Temperatures between 33° and 50° F appear to be optimum, although some researchers have noted benefits from storage below 32° F. The family refrigerator is usually set at about 40° F, which is satisfactory for seed storage.

Germination of Seeds

External Requirements for Germination

Germination can occur only when the seeds themselves are ready and when the environment is right. The major factors regulating

germination are available water, appropriate soil temperature, sufficient oxygen, and sometimes light.

Permeability of the seedcoat determines the rate at which water is absorbed by seeds. Impermeability is a problem with only a few gymnosperms.

Temperature also can have an important influence on germination of gymnosperm seeds. Some have extremely specific requirements while others germinate over a wide range of temperatures. Most seeds germinate best at temperatures slightly higher than those required for optimum growth following germination. Diurnal temperature fluctuations often result in a higher percentage of germination than does a constant temperature. At the Arnold Arboretum, seeds are sown in late winter or early spring in a greenhouse where the minimum temperature is 70° F. On warm, sunny days temperatures in the house may reach 90° F or more.

Energy used by the seed for germination is provided by a process called respiration. During this process oxygen changes stored sugars, starches, and oils to energy, water, and carbon dioxide. If insufficient oxygen is available in the soil air, germination is inhibited. Lack of oxygen is a problem only if the soil is too wet or compacted, or if the seed is planted too deeply.

Light appears to play a role in the germination of some gymnosperm seeds (i.e. *Tsuga*), while others germinate well in total darkness. Only certain colors of the spectrum are important. Red light promotes germination while far-red light acts as an inhibitor. Since red light penetrates the soil to only about an inch, seeds that have a light requirement and are planted deeper than an inch will not germinate.

Internal Requirements for Germination

Simple or Embryo Dormancy

Seeds of some species, including a few pines and some lots of false-cypress and arborvitae, require no more than a satisfactory external environment (i.e. sufficient water, heat, light, and oxygen) for germination. Other species have internal factors that inhibit germination despite favorable external conditions. Germination may be inhibited by embryos that are not fully developed although the seed appears mature. A period of after-ripening, during which the seed is exposed to cold under moist conditions, usually overcomes this dormancy.

In nature, after-ripening requirements are met by low temperatures and dampness when seeds overwinter out-of-doors. Dormancy is a natural adaptation preventing germination when weather is unfavorable for seedling survival. Without this protection, seeds could germinate during a warm period in late autumn and perish in sub-

sequent cold. Some nurserymen provide natural after-ripening by sowing seeds out-of-doors in the fall and allowing nature to fulfill the cold requirements.

Alternatively, a period of artificial cold may be employed in after-ripening seeds. Stratification is the term commonly used to describe this procedure. The word is derived from the practice of placing seeds in boxes between layers, or strata, of a damp medium before exposing them to cold. Stratification now is interpreted as any process used to encourage germination of dormant seeds that require pretreatment by time and temperature. It tends to hasten and synchronize germination of most gymnosperm seeds, even those that exhibit no dormancy.

Seeds can be stratified by placing them in a refrigerator for a period of time. There is some leeway in refrigeration temperatures, but 40° F has proven satisfactory. Seeds should not be placed in the freezing compartment.

A polyethylene bag is excellent for stratifying seeds since it allows air exchange but prevents water loss. Large quantities of seed can be stratified in barrels, boxes, or cans. Seeds should be layered or mixed in the container with a stratifying medium. At the Arnold Arboretum, a combination of equal parts of sand and peatmoss is used, but other media such as sand and well-weathered sawdust are also satisfactory. The stratifying medium is dampened carefully, since a wet, soggy medium reduces the amount of available oxygen. The volume of the stratifying medium should be no more than two or three times that of the seeds. This is enough to stratify the seeds effectively, but eliminates the need to separate them from the stratification medium before sowing.

Depending on the species, gymnosperms require stratification of one to several months. Stratification should be timed to allow sowing of the seed in the lengthening days of late winter or early spring, when light and temperature conditions are favorable for seedling growth and survival.

Double Dormancy

Sound seeds of some gymnosperms (for example, *Juniperus*) are prevented from germinating by impermeable seed coats that hinder the admission of water, as well as by immature embryos. Such seeds are said to be doubly dormant, since two conditions must be overcome before germination can take place. In nature, it takes two or more years for these seeds to germinate. They often are termed two-year seeds.

In many cases, impermeable seed coats can be altered by a process called scarification, during which the seed coat is modified by scratching and breaking it to allow water penetration. Seeds can be rubbed

with sandpaper or scored with a file (mechanical scarification), or they can be placed in strong acid. Impermeability in a number of pines is best overcome by acid scarification. Dry seeds are placed in a glass container and covered with concentrated sulfuric acid. The mixture is carefully stirred periodically with a glass rod and the seed coats checked for degree of erosion. They should be extremely thin, but not eaten through all the way. As soon as they are sufficiently eroded, the acid is poured off and the seeds are washed thoroughly.

Acid scarification should be approached with great care by the amateur since sulfuric acid is highly corrosive and spatters violently upon contact with water. Protective clothing should be worn and used acid should be disposed of outside in unused soil rather than poured down a household drain.

Frequently, the most effective way of breaking down seedcoats is to expose the seeds to a period of warm, moist conditions during which micro-organisms decompose the seed covering. This treatment is called warm stratification, and it must precede cold stratification. For many doubly dormant seeds, a period of five months' warm stratification makes the seedcoat sufficiently permeable for cold stratification to be effective.

The moist medium used for warm stratification must contain some unsterilized material so that micro-organisms will be present. Ordinary garden soil is satisfactory; at the Arnold Arboretum a combination of equal parts of sand and peat moss is used. Sphagnum moss should not be used since it contains a natural antibiotic. Seeds are mixed with the stratification medium, placed in a polyethylene bag, and set in a location where the temperature will fluctuate. Window sills and greenhouse benches are suitable. There is some latitude in temperatures for warm stratification. Temperatures fluctuating between 60° and 100° F have produced good results. Seeds should not be exposed to full sun since this may cause detrimental build-up of heat within the polyethylene bags. Bags should be checked periodically for possible germinating seeds, and the medium dampened if necessary.

Immediately following warm stratification, seeds can be transferred to refrigeration units for cold stratification without opening the bags. When cold stratification facilities are unavailable, doubly dormant seeds can be sown out-of-doors and allowed to experience seasonal temperature changes.

Sowing

Small quantities of seed may be sown in any container that can be sterilized and that provides adequate drainage. Styrofoam cups, plastic flats, and seed pans are suitable. Tin cans with holes punched in the bottom also are quite satisfactory.

Technique for sowing very fine seeds. Even distribution is achieved by tapping the hand holding the folded card in which seeds are placed. Photo: P. Chvany.

The medium used should be loose and well drained, maintaining an even supply of moisture for the germinating seeds. Many excellent prepared and sterilized mixes are available at nurseries and garden centers for reasonable prices. An adequate growing medium can be prepared in the home by combining one part sand, one part loam soil, and one part screened peatmoss.

At the Arnold Arboretum, the growing medium is placed in the container and covered with a layer of milled or screened sphagnum moss. Seed is distributed over the surface of the prepared containers and covered with a second layer of sphagnum. It is not necessary to separate seed from stratification medium.

If the container used is a tall vessel, such as a can, it may be necessary to fill the bottom with a coarse material, such as pot shards or stones, before adding soil medium and seeds. Sphagnum moss or leaves can be placed over the coarse material to prevent the soil mix from sifting through and blocking drainage.

The container should be filled to within ½ inch of the top. Later when the remaining space is filled with water, it provides exactly the volume needed to wet and leach the container's contents thoroughly. To dampen the soil medium initially without disturbing the seeds, the container can be placed in a vessel of water deep enough to reach above the material used for drainage. Capillary action conducts the water upward through the container, wetting its contents. Completed containers are placed on a greenhouse bench or on a window sill.

Watering

Water is one of the most important factors influencing seedling germination. Because germination occurs in the upper surface of the soil medium where the atmosphere has a constant drying effect, maintenance of even moisture may be difficult. Under greenhouse conditions, atmospheric humidity is usually maintained at high levels and drying of the soil surface is greatly reduced. In the home, drying can be avoided by placing the seed pans in polyethylene bags and sealing them tightly. A high humidity is maintained inside the bag and water should not be needed until the seedlings have germinated. It is important that the bag not be exposed to direct sunlight, since this will cause build-up of heat.

After germination, the plastic cover must be removed, as the seedlings become too succulent when grown in a close atmosphere. Rather than remove it all at once, the bag should be opened for lengthening periods over several days to allow the seedlings to become accustomed to a less humid atmosphere.

Disease Control

Gymnosperm seedlings are particularly susceptible to damping-off diseases — fungus-caused disorders that attack seedlings. The fungi

invade stem tissues beneath or near the soil surface, causing seedlings to die. These diseases can destroy entire flats in a day and are best controlled by careful, preventive cultural techniques.

Sterile soil and containers are absolutely necessary. Soil mixes can be sterilized by heating them in a 180° F oven for thirty minutes. Insects and most weed seeds will be killed as will most disease organisms. Flats and seed pans can be sterilized by soaking them in disinfectants such as 10 per cent household bleach solution. Clay or metal containers may be heated in an oven or immersed in boiling water to prevent disease problems.

Sowing seed between two thin layers of milled sphagnum reduces the chance of damping-off since its antibiotic properties discourage damping-off fungi. The sphagnum should be unsterilized, since it is a bacterium in the moss that produces the antibiotic.

Stratification of gymnosperm seed hastens and unifies germination, discouraging the development of disease organisms and permitting early separation of the seedlings. Development of fungi can be limited by watering early in the day so that seedlings dry off quickly, and by providing ventilation to evaporate excess water.

If damping-off does occur, drenching with a fungicidal material specific for the purpose will help to reduce losses. A number of highly satisfactory preparations are available.

After-care of Germinated Seedlings

Newly germinated seedlings grow rapidly and soon compete with each other if not separated. They should be moved into pots or flats or lined out in beds where they can develop under uncrowded conditions. Flatting and lining out are preferable to potting since young plants in pots often develop circling root systems that may girdle them in later years. During their first summer, young plants should be provided with shade to protect them from scorching, both in and out of the greenhouse.

In autumn, woody temperate-zone plants go dormant and must be given a period of cold before they will grow again. They should not be planted in the open ground, since repeated freezing and thawing through the winter months causes small plants to heave. A naturally lighted cold storage facility such as a cold frame will give young plants the protection they need, at the same time providing them with the necessary cold period. Attention should be given to venting and shading if the frame is exposed to the sun.

ASEXUAL PROPAGATION

Vegetative propagation is based upon the ability of many plant parts to produce missing essential organs when severed from the parent plant. Shoots can be induced to generate roots, and roots

may produce stems and leaves. Separate shoots and roots may, when joined together, form bridging tissue to make one entire plant.

Advantages of Asexual Propagation

Though reproduction from seeds is the most common and natural way of producing plants, there are numerous advantages to vegetative reproduction.

Some gymnosperm species are easier to reproduce asexually than sexually. Many yew seeds, for instance, germinate slowly due to embryo dormancies, yet most taxa of this evergreen root quite easily. Usable plants are produced more quickly and less expensively by asexual techniques.

Plants that produce no viable seed because they are sexually immature, are fixed juveniles, or are dioecious, can be propagated only asexually. Finally, propagants identical to the parent plants can be produced, preserving their unique characteristics and eliminating the problem of genetic variation. Plants derived asexually from a single original plant are all members of a specific "clone" and maintain its distinguishing characteristics. These characteristics may not be duplicated in all of the plant's sexual progeny. Cultivars and hybrids are generally propagated asexually for this reason.

Disadvantages of Asexual Propagation

The only serious disadvantage to asexual propagation is that it may perpetuate a number of plant pathogens (fungi, bacteria, and viruses). Some of these, particularly the viruses, cause permanent changes in the clone, and most affect plant growth adversely. Scrupulous use of disease-free propagating material and tools generally eliminates the problem. Material should be taken only from healthy plants that have developed normally and possess the desirable attributes of the clone. Propagating stock should be examined carefully to determine whether or not it is infected with pathogenic organisms. Attacks by fungi and bacteria usually produce obvious evidence, but the presence of a virus may not be easily detectable in all clones or at all seasons.

Types of Asexual Propagation

Cutting

A cutting is a plant part removed with the intention of inducing it to generate the organs that will allow it to function independently. Propagation by cuttings is usually preferable to grafting because plants are produced on their own roots and the possibility of incompatibility between stock and scion is avoided. No special manual skills are needed for cutting propagation.

Only stem cuttings are important in the propagation of gymnosperms. They are taken from branches or shoots and bear preformed vegetative buds from which new shoots will arise. Roots alone must be generated to turn a stem cutting into a functioning plant.

Stem cuttings may be taken from plants in either hard- or softwood stages. Hardwood cuttings are those taken in fall or early winter from mature shoots that have ceased growth and become woody. Requiring less care than softwood cuttings, they are not especially perishable and can be shipped long distances safely. Most gymnosperms root best from hardwood cuttings.

Softwood cuttings are taken in spring or early summer from new growth of the current season that has not fully matured. Because softwood cuttings are actively growing when severed from the parent plant, they lose a great deal of water to the air through transpiration. Since they have no roots to take up water and replace this loss, the cuttings soon wilt unless placed in an atmosphere of high humidity. Softwood cuttings generally root more quickly than hardwood cuttings; a number of gymnosperms can be propagated in this manner.

Selection of Cutting Material

Cutting material should be taken from plants that are free from disease and insect pests and show normal growth. For best results

vigorous shoots with long internodes should be avoided when possible. Both lateral and terminal shoots may be taken, though there is some evidence that terminal shoots may root less readily than lateral ones. Some gymnosperm species produce diverse plant forms, depending on whether they are propagated from lateral or terminal shoots. For example, only cuttings taken from terminals or upright laterals will reproduce the normal upright form of Japanese yew, *Taxus cuspidata* 'Capitata'.

In some cases, cuttings taken close to the ground are more likely to root than those taken higher on the plant, since they tend toward an immature phase termed "physiological juvenility."

Longer shoots may be sectioned into several cuttings, but there may be some variation in root formation on cuttings taken from different parts of the same shoot. In the case of hardwood cuttings, the lower parts of the shoots root better than the tips; with softwood cuttings, the new growth of the tip generally roots more satisfactorily.

For some unknown reason, cuttings taken from plants growing in a greenhouse will frequently root successfully while comparable material taken from out-of-doors does not.

Physiological Juvenility

As young seedlings, plants go through an immature phase called "juvenility." Characteristics of young seedlings often differ from those found later in the plant's life. Cuttings of many plants that are difficult or impossible to root in the mature phase root easily in the juvenile phase.

In some instances, the change from juvenility to maturity fails to take place and the juvenile characteristics remain. Such plants have been called "fixed juveniles," and they root as easily as do seedlings of the same species regardless of age.

Procedure for Taking Cuttings

An effort should be made to gather softwood cuttings early in the morning before much transpiration has taken place and while they are in their freshest, most turgid condition. Hardwood cuttings may be taken any time of the day.

Cuttings should be removed from the parent plant with a clean sharp tool. The cut should be immediately above a bud, leaving no stub.

Cutting size is dependent on the growth rate of the plant that is to be propagated. Some gymnosperm cultivars produce less than ½ inch of growth in a single year so that, unless the stock plant is to be destroyed, only small cuttings can be taken. At the Arnold Arboretum, large cuttings consisting of two or three years' growth are usually preferred. Not only do they contain greater food resources, which lead to quicker rooting and more extensive root systems, but

Collected cuttings placed in a plastic bag bound at the mouth with a rubber band. Air remains inside so bags can be piled on one another without crushing contents. Photo: P. Chvany.

Portion of cutting that will be in rooting medium must be stripped clean of leaves and twigs. Photo: P. Chvany.

they produce plants of usable size more rapidly. Immediately upon collection, cuttings are placed in a polyethylene bag tightly sealed with a rubber band to prevent drying. Air is not squeezed out of the bags when cuttings are taken, since it provides a cushion that allows the bags to be placed on top of each other without crushing the contents. To prevent build-up of heat within the bags, they are shielded from the sun. A large capacity styrofoam picnic cooler may be used to protect freshly collected softwood cuttings.

After collection, the bags of cuttings are placed in a refrigerator to retain freshness until processed. It is best to handle all cuttings (particularly softwood) as soon as possible.

Processing of Cuttings

Cuttings are prepared for insertion by removing all twigs and leaves from the portion of the stem that will be in the propagating medium. If allowed to remain, this material may decompose, inviting infection from pathogenic organisms.

Removal of these parts also creates small wounds on the cutting. These wounds remove a physical barrier to root emergence, exposing a larger area to the action of root-inducing substances and en-

Cuttings of Taxus *showing various sizes. All will root, but heavier cuts on right tend to root faster and will produce usable plants sooner. Photo: P. Chvany.*

couraging formation of a more extensive root system. Frequently, wounding stimulates the development of protective tissue called callus, which is composed of undifferentiated cells. Callusing may precede rooting but is independent of it.

Cuttings are usually treated with root-inducing materials. Indolbutyric Acid (IBA) has proven satisfactory and is used extensively. Naphthalene-acetic acid (NAA), indoleacetic acid (IAA), and 2, 4, 5-trichlorophenoxy alpha propionic acid (2,4,5-TP), also are used. All but the last are commercially available in a number of different preparations, including combinations. IBA and NAA combined lead to excellent rooting response in certain cases. A fungicide added to the material also improves rooting, a synergistic effect not yet explained by plant physiologists.

Root-inducing substances are available in different concentrations. In general, the more difficult a taxon is to root, the higher the required concentration. For example, certain yew and arborvitae, and creeping juniper root well when treated with a powder formulation containing 3 mg IBA/gm of talc. More difficult taxa respond better to a concentration of 8 mg/gm of talc.

Root-inducing powder is applied to the basal parts of cuttings by dipping them into enough powder to coat the newly cut surfaces, then tapping them to remove any surplus. The cut surfaces are generally moist enough so that the rooting powder will adhere and wetting is unnecessary. It is advisable to estimate the amount of rooting material needed and transfer it to a separate container, discarding what is left after treatment, since dipping cuttings directly into the main supply moistens and contaminates it.

Liquid formulations of rooting materials are purchased in concentrations that can be diluted with tap water. Only enough solution should be prepared for the work at hand, since it too becomes contaminated when cuttings are dipped into it.

Rooting Medium

The rooting medium performs three functions. It holds the cutting in place, serves as a reservoir for water, and allows air to reach the cutting base. Sand, peatmoss, sphagnum moss, vermiculite, and perlite, among other things, are used as propagating media, frequently in combination. Any medium should be free of extraneous organic matter, such as dead leaves and twigs, that may introduce pathogenic organisms.

At the Arnold Arboretum, a one-to-one mixture of coarse sand and horticultural grade perlite is used for conifers. Perlite improves the physical structure of the medium, preventing compaction of fine particles of sand and allowing the removal of cuttings with less possibility of root damage.

When dealing with extremely small cuttings, such as those often taken from dwarf conifers, a mixture of sand and peatmoss sifted is substituted for the sand and perlite mix.

Root initiation is hastened by supplemental heat in the rooting medium. Thermostatically controlled electric heating cables buried below the root zone can be set at optimum temperatures for the cuttings being rooted. At the Arnold Arboretum, bottom heat is maintained at 75° F.

The depth to which cuttings are inserted depends to a certain extent upon the size of the cutting. The bases of large cuttings may be as much as ⅜ inch in diameter and will require insertion to a depth of 2 inches or more for adequate support. Smaller cuttings may be inserted more shallowly.

Before inserting cuttings, a hole is made in the rooting medium large enough to accept the cuttings without brushing off the rooting compound. For large numbers of cuttings, a single long slit can be formed by drawing a thick knife through the medium using a straightedge as a guide (metal instruments are less likely to carry infection than wooden ones.)

It is important that the cuttings be uncrowded in the bench. Enough space should be left between them to allow for free air circulation. Light should be allowed to reach the surface of the rooting medium to discourage the growth of harmful organisms.

Labeling is necessary to prevent confusion. Plastic labels are sanitary, can be marked with a graphite pencil, and remain legible for several years.

Cuttings should be arranged systematically in the medium. One method is as print runs in a book: starting on the left, cuttings are

inserted in a line from front to back. When one line of cuttings is completed, the next begins in front again. A label precedes each lot of cuttings.

Once planted, the cuttings are heavily watered to compact the medium around them.

Propagating Structures for Cuttings

At the Arnold Arboretum, hardwood cuttings are propagated in winter either in open greenhouse benches or under polyethylene plastic, which maintains an atmosphere of high humidity. The benches, peninsular in design, are 6 by 5 feet wide, and 6 inches deep. They are constructed of ¾-inch transite. Each is completely lined with two-mil polyethylene plastic and 1½ inches of rooting medium is placed in the bottom. Heating cables are installed at this level and cover with ½-inch mesh hardware cloth. This promotes even distribution of heat by conducting it away from the cables.

The polyethylene plastic covering over the bench is supported by a frame of 2- by 4-inch welded-joint wire mesh. This is known as turkey or utility wire and is obtained at farm supply stores. Purchased by the roll, it can be cut and bent into any shape. The frames are fashioned to hold the plastic about 10 inches above the rooting medium.

It is important that this framework lie flat on the top, rather than in a curve as is sometimes suggested. Temperatures within the propagating unit are warmer than the surrounding atmosphere and water continually condenses on the inner surface, accumulating in heavy droplets. These fall on the cuttings and into the medium, creating an environment of continual moisture. A flat surface above permits even distribution of the falling drops, whereas a curved top directs them to the sidewalls and down, leaving the center portion of the cutting bed dry.

In recent years elaborate mist systems have been employed for the propagation of softwood cuttings, preventing the cuttings from desiccating even in full sunlight. However, both hard- and softwood cuttings can be rooted satisfactorily in polyethylene enclosures. At the Arnold Arboretum, fall and winter cuttings still are rooted either in these structures or on an open bench even though mist systems were installed in 1962.

The chambers have some distinct advantages for amateurs. They are inexpensive and relatively carefree. There is little chance of loss through mechanical or human failure. Nutrients do not leach from the leaves as can happen under mist when cuttings require a long period to root. In areas where hard water presents a problem, there is no build-up of minerals on the cuttings.

Small numbers of cuttings can be rooted by amateurs in far less elaborate (but equally satisfactory) structures than those used at the Arnold Arboretum. A simple polyethylene bag, filled with root-

ing medium and placed in a container to give it support, is quite adequate for the rooting of most cuttings. Once the cuttings are inserted and watered-in, the bag should be bound at the mouth with a rubber band. This little propagating unit can be placed on a north window sill where cuttings will not be exposed to direct sunlight. It is important that the bag be set inside the container rather than the other way around, for water condensing on the bag's sides then can run back into the rooting medium.

A simple enclosure for outdoor propagation can be constructed for softwood cuttings. First, a site is chosen that offers as much light as possible without direct sunlight. (A location open to the sky and on the north side of a house, wall, or tree would be ideal.) A standard 1- by 2-foot greenhouse flat is pressed against the earth to show its outline, and the soil is then excavated to a depth whereby the flat's edges will be level with the surrounding soil. Two-mil polyethylene plastic is cut to line the flat with enough surplus so that it extends about 6 inches on all sides. A shallow excavation in the ground, framed with boards and lined with plastic to keep the surrounding soil from contaminating the rooting medium, could also serve as a container.

Medium is added to the container, slightly firmed, and the cuttings are inserted and watered. A flat-topped turkey wire frame, cut and bent to support the polyethylene plastic about 6 inches above cuttings, is placed over the container. The frame is covered with polyethylene and soil mounded over the plastic where it meets the ground to form a seal.

After-care of Cuttings

On cloudy, humid days, polyethylene coverings are removed and the cases checked for fallen leaves and dead cuttings which, if allowed to remain, would decay and invite disease. Cuttings should be checked weekly for symptoms of fungus and, if necessary, sprayed with a fungicide. Watering is seldom required.

After several weeks, the first signs of rooting may be observed. Cuttings may be checked by giving them a gentle tug. Heavy resistance indicates good roots; slight resistance, small roots; and no resistance, no roots. Occasionally, a ball of callus tissue forms at the base of cuttings but even after an extended period no roots appear. This tissue may be removed, the cuttings retreated with root-inducing material, and returned to the propagating chamber for a second try.

Once cuttings are rooted, they should be carefully lifted from the medium and potted or flatted in a suitable growing medium. Material rooted under conditions of high humidity and temperature must

Above left: A hole is made in the medium to prevent root inducing material from being rubbed away when cutting is inserted. Photo: P. Chvany.

Below: Section of propagating structure showing labelling arrangement and framework of 2- × 4-inch welded joint wire used to support polyethylene plastic film. Photo: P. Chvany.

be brought into normal atmosphere gradually. This is done by again covering them with polyethylene.

On cloudy, humid days the plastic can be removed; if several such days occur in succession, the transition will be complete. Otherwise, the cuttings may be uncovered at night and recovered during the heat of the day for a period of five or six days.

Layering

Layering is a simple but highly effective technique by which plants may be reproduced. It is perhaps the easiest of the asexual methods for amateurs to practice. Plants propagated by cuttings require special equipment to maintain a humid atmosphere so that excess water is not lost to the air. Layers remain attached to the parent plant and are sustained by it until sufficient roots have formed to make them self-sustaining. Water lost by transpiration from the leaves of branches being layered is replaced by the roots of the parent plant. As no facilities are needed for layering, it is the ideal method for amateurs who wish to propagate a few plants in their yards.

Layering of trees and shrubs can be done wherever the soil is workable.

Common or Simple Layering

The only type of layering suited to gymnosperm propagation is common or simple layering. Branches selected for common layering should be limber enough to be bent to the ground. Each branch is first arched to the ground and a line is scratched parallel to it and about a foot behind the branch tip. This scratch mark is used as a guide for digging a trench parallel to the bent branch and sufficiently deep to cover it.

The branch is fitted into the trench in such a manner that the tip can be bent into a vertical position. At the point where the branch turns sharply upward, it is girdled by cutting two parallel rings about ½ to 1 inch apart through the bark and around the branch. (This creates a block that intercepts the downward movement of auxins and other materials manufactured by the leaves and buds. A bulge forms above the girdle as these substances collect, and rooting is initiated at the swollen area.) The bark between the cuts is removed and the branch returned to the trench and pegged immediately behind the girdle with a heavy stone or a large staple made from a coat hanger or a forked branch. The tip of the branch above the girdle is then raised to an upright position with the girdle remaining at the lowest point in the bend. The trench is filled with soil and the branch tip staked to keep it vertical.

In the event the soil is poor at the layering site, a good, well-drained soil mix should be substituted in the trench when it is refilled. During periods of dryness, the soil in the area of the layer should not be allowed to dry out.

By carefully removing some of the soil covering the layer, it is possible to check the extent of root development. If adequate roots have formed in one growing season, the layer can be severed from the parent plant and moved to its new location. Some plants may require two growing seasons to form enough roots to sustain themselves. After being separated from the parent plant some conifers will require staking for several years in order to encourage upright growth.

Grafting

Grafting is the process of joining roots of one plant to the shoot of another so that they unite, grow, and function as a unit. The root portion of a graft is called the "rootstock" or "understock," and the shoot portion is termed the "scion."

Grafting requires time, skill, and special after-care, making it the most expensive method used to reproduce plants. When plants fail to produce seed or will not come true from seed, when they refuse to root from cuttings and are impractical to layer, they are grafted. In the past, many gymnosperms were grafted as a last resort because they did not come true from seed and were difficult to root. Advances in cutting propagation, such as the use of rooting compounds, mist units, and polyethylene enclosures, have made grafting less important in conifer propagation. A number of taxa that were grafted previously now can be rooted as routine practice.

Compatibility

The most important factor in establishing a successful graft union is compatibility between rootstock and scion. When two species are incompatible, the rootstock and scion may fail to form connecting tissue that knits them together into a strong union. Movement of water and nutrients between rootstock and scion is partially or wholly restricted and the plant fails.

Many incompatible grafts fail immediately, the young plant never commencing growth following grafting. Others appear to grow for a period of weeks, months, or even years before failing.

The direct evidence of incompatibility may be abnormalities such as swellings at the graft union. The weak junction between stock and scion is susceptible to breakage, sometimes splitting cleanly apart in a wind storm, even after years of apparently normal growth.

In general, the more closely related botanically the two taxa are, the more likely they are to form a successful graft union. Grafting a variety on its species is almost always successful, but compatibility between species in a genus is highly variable. Though there is no reliable test for predicting incompatible combinations, trial and error have resulted in a number of recognized compatible combinations used commonly by nurserymen.

1. Pinus strobus, *2.* P. cembra, *3.* P. flexilis, *4.* P. parviflora, *5.* P. bungeana, *6.* P. rigida, *7.* P. virginiana, *8.* P. thunbergii, *9.* P. sylvestris, *10.* P. densiflora, *11.* P. banksiana, *12.* P. nigra, *13.* P. resinosa.

Selection and Storage of Scions

Gymnosperms are grafted in winter or early spring. Scions for grafting are collected late in the fall, after the plants have gone dormant and the buds have been exposed to a cold period. Only healthy wood of normal growth should be chosen. Shoots with long internodes that have grown rapidly make poor scion material. Wood with abnormalities of any kind should be rejected (unless the purpose of propagation is an attempt to reproduce the abnormality). Healthy, well-developed, vegetative buds should be present on the scion wood. Terminal growths of tree forms should be taken whenever possible, as the grafted plants require less training to produce normal, upright trees.

After collection, scion wood must be carefully stored to prevent desiccation of the wood and development of the buds. When a refrigerator is available, scions can be stored in sealed polyethylene bags at about 40° F. Alternatively, they can be stored in a box of

slightly dampened sphagnum moss, peatmoss, or sawdust in a cool location. Excess moisture will cause deterioration.

All scions in storage should be distinctly labeled.

Selection and Preparation of Rootstocks

Both seedlings and rooted cuttings may be used as rootstocks for gymnosperm propagation. Cuttings of easily rooted taxa are used for those clones of false-cypress, juniper, yew, and arbovitae that are not easily rooted themselves. Seedling rootstocks are least expensive to produce, but they require more time to reach a usable size than do rooted cuttings. Rootstocks must be of a species compatible with the scion, and are best potted one growing season ahead of grafting so that a firm rootball will develop. Such understocks prepared in advance are called "established understocks." After potting, seedling understocks are plunged in an outside frame during the summer for storage and growth. In early winter, after they have been dormant long enough to satisfy cold requirements, they are brought into the greenhouse to be forced into active growth in preparation for grafting.

Rootstocks can be grafted as soon as they break dormancy and begin growth — usually three to four weeks after being placed in the greenhouse. They need not have begun topgrowth. If the root-tips show new growth, the plant is ready for grafting. At the Arnold Arboretum, most gymnosperms are grafted in January and February.

Tools

Two pieces of equipment, a knife and suitable tying material, are needed for grafting. The knife should be well-made of a high-quality steel. Good knives have folding or fixed blades, usually beveled on only one side. The blade is straight, about 3 inches long, and firmly hafted deep in a handle that fits comfortably into the user's hand.

The tying material can be grafting tape, grafting thread, or rubber strips that are used as wrapping to hold scion and understock together until the two unite. At the Arnold Arboretum, $^{3}/_{16}$-inch-wide strips of rubber, made especially for grafting or budding work and available commercially, are wound around the union from bottom to top. These are secured by slipping the end of the rubber strip under the last turn taken. An ordinary cut rubber band also would be satisfactory. If exposed to sun and air, it rots away. Below ground, the rubber does not deteriorate and can girdle small plants if not removed.

Wax is not used for conifer grafting, since natural resins seal the graft union, preventing desiccation.

Grafting Techniques

A successful graft union depends on new cells formed by the scion and rootstock that mingle and interlock. These cells originate from

a ring of tissue just under the bark of rootstock and scion called the "cambium layer." The cells form callus tissue which eventually gives rise to new cambial and vascular tissue, forming a completed graft union.

To insure a graft union, it is important that the cambial layers of stock and scion be placed against each other in such a manner that callus formation is promoted. (Cambium layers are usually green, sometimes red, and are easily exposed by a cross-section cut through scion and rootstock.) All grafting techniques are designed to allow close cambial contact. Only the side graft, the veneer graft, and the whip-and-tongue graft are customarily used in grafting gymnosperms.

Side Graft

To prepare the stock plant for side grafting, branches are removed from the stem for several inches above the soil line. The side with the least knots and blemishes is selected and a shallow downward cut about 1½ inches long is made through the bark and cambium and into the wood to form a small tongue. The scion is then prepared by removing two slivers of different sizes from either side of its base. To complete the graft union, the scion is fitted to the understock so that the cambial surfaces are united and the tongue covers the outer cut. Care must be taken to match as much cambial surface as possible. If the understock is larger than the scion, fitting should be done so that the cambium layers are in contact at the bottom and along one side. The combination now is ready for binding with a rubber budding strip. Top growth remains on the understock of the grafted plant until the scion has come into growth; it then can be removed in either one or two stages depending on the subject being propagated.

Veneer Graft

This is a widely used variation of side grafting. The stock plant is prepared by removing a piece of bark and wood from the area just above the soil line with two cuts. One cut, downward and slightly inward, is about 1½ inches long. The second cut is short, downward and inward, about three-quarters of the way down the first cut and intersecting it. A short spur of bark and wood is left at the base of the long cut.

The scion is also prepared with two cuts — a long shallow one on one side of its base and a short slanting one on the opposite side. It is then fitted into the rootstock, cambium layers carefully matched, and the union bound with a rubber strip. As with the side graft, the top growth remains on veneer-grafted plants until the scion begins active growth.

Veneer Graft. Drawing: M. Givens.

Side Graft. Drawing: M. Givens.

Whip-and-Tongue Graft. Drawing: M. Givens.

Whip-and-tongue Graft

This is the only grafting technique used for gymnosperms in which the top growth of the stock plant is entirely removed prior to grafting. A sloping cut is made through the stem after the top growth is removed. A second, downward vertical cut is made through the surface exposed by the first cut, forming a small tongue of wood.

To prepare the scion, a long sloping cut is made at its base, the same length as the first cut on the stock plant. A second cut is made through the first, forming a thin tongue similar in size to that of the stock plant. To form the graft the tongues of stock and scion are tightly fitted together so that they are immovable. They should be joined with as much cambial contact as possible. When a scion of small diameter is grafted on a larger understock, care should be taken that the cambium layers meet on at least one side. The completed graft is bound with a rubber band.

After-care of Grafts

Following grafting, plants are plunged in a greenhouse bench with bottom heat. This encourages the development of callus tissue, the first step in the formation of a graft union. The graft union should be completely covered with dampened peatmoss to prevent desiccation as the cut tissue knits.

As callus tissue forms and growth activity begins to appear on the scion, the top growth of the understock, if it remains, may be reduced. This is usually done in two steps, half the top growth being removed first, the remainder at a later date, when growth of the scion is well advanced.

In the spring, after danger of frost is past, young grafted plants can be planted outside. They should be placed with the graft union below the surface of the soil to encourage formation of roots on the scion. Before placing them outside, the grafting rubbers must be removed, since they will not deteriorate beneath the ground.

Budding

Budding is a form of grafting that makes use of a single vegetative bud as a scion. Large numbers of plants can be budded quickly and efficiently, a smaller quantity of scion stock material is required than would be needed for grafting, and no special facilities are needed.

Budding is done when the stock is growing actively, its bark can be separated easily from the wood, and the scion buds are well-developed.

To prepare for summer budding, shoots of the current season's growth are cut. To reduce transpiration, the soft tip and leaf blades are removed. About ½ inch of the petiole is allowed to remain to

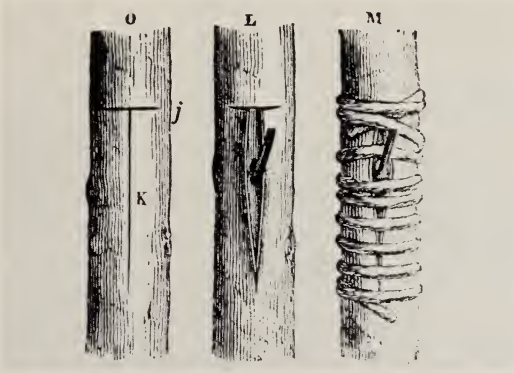
serve as a handle when processing the buds. At this stage the shoot is termed a bud stick. Bud sticks must be kept in fresh condition until ready for use. When stored in a cool place in sealed polyethylene bags they will keep in good condition for a week or more.

The most common budding technique is shield or T-budding. These names are derived from the shield-like appearance of the prepared scion and the T-shaped cut that is made in the stock plant.

To remove the bud scion from its stick, a cut is made from about ½ inch below the bud to about ½ inch above it, forming a small oval shield. The shield should be thin but not too flexible. Some propagators recommend removing the sliver of wood attached to the shield behind the bud. At the Arnold Arboretum, however, this is allowed to remain, since its removal may damage the bud or leave an air space immediately behind where it is joined by the rootstock.

To insert the bud in the rootstock, a T-shaped incision is made through bark and cambium to the woody layer beneath. The flaps of bark thus formed are raised from the wood and the bud shield slipped between them and forced downwards into the slit. The bud should be positioned well below the horizontal cut, so that the flaps may be closed above it. To hold the bud in place, commercially available rubber budding strips or plastic bud ties are wrapped above and below it. In about a week, success or failure can be determined. If the portion of petiole accompanying the bud falls away when tapped, the bud has taken; if it is shrivelled and attached, failure is indicated and a second attempt can be made by inserting another bud in a different location.

Examination in early spring will reveal whether or not the bud is still alive. If so, the understock is cut away about ½ inch above the bud. An occasional inspection after growth begins will reveal whether sprouts are developing on the stock beneath the bud. These can be removed quickly by hand rubbing while they are still soft.



Shield budding showing T-shaped incision, inserted bud, and twine binding. From Charles Baltet, L'Art de Greffer. *Paris. 1885.*

GENERA

ABIES: **Fir**

There are about forty species of fir native to the Northern Hemisphere. They are evergreen trees of pyramidal habit. Except for their cultivars, fir trees are commonly propagated by seed.

Sexual Propagation

Male and female cones of *Abies* are borne on the same tree. The oblong female cones stand erect on branches of the previous year's growth and are composed of thin, closely spaced scales, each having two seeds at its base. Cones ripen in autumn of their first year and shatter from the top down, releasing winged seeds to wind dispersal. Since the cones shatter shortly after they mature, they should be collected as soon as possible after ripening. They are attached to the tree by short woody stalks and must be cut free. After the cones dry, seeds may be separated from the scales by screening and fanning techniques.

Fir seed loses viability in less than a year if kept in dry storage. To assure high percentage of germination, it should be sealed and placed in controlled cold storage until time for stratification. *Abies* seed exhibits embryo dormancy, which can be overcome by two or three months of cold stratification at 40° F. Because the seedlings are particularly susceptible to damping-off organisms, pretreatment should be planned to coincide with the lengthening days of late winter or early spring. If stratification is extended beyond the three-month period, the seeds tend to germinate in the cold. Depending on the species and seed lot, germination takes from one to three weeks.

Asexual Propagation

Cutting

At the Arnold Arboretum, cuttings of some abnormal *Abies* cultivars have rooted in high percentages. When treated with a rooting compound containing 3 mg IBA and 150 mg Thiram (a fungicide) per gram of talc, three out of four cuttings of *Abies koreana* 'Prostrate Beauty', taken in June were rooted. *Abies balsamea* 'Nana' cuttings taken in December rooted almost as well when treated with a rooting compound containing 8 mg IBA per gram of talc, plus a fungicide.

Grafting

Choice of understocks for the grafting of fir trees is less limited than for many genera. *Abies alba* and *A. balsamea* are generally considered suitable understocks for all *Abies* clones. *Abies nordmanniana* is compatible with most short-needled firs, and *A. concolor* with those having long needles.

Scions taken in January and February are side-grafted on established understocks potted one growing season in advance of their use. The plants are then plunged in peatmoss to a depth that covers the graft union.

These graft combinations have survived a significant number of years at the Arnold Arboretum.

Rootstock	Compatible Scion
Abies balsamea	*Abies alba*
	A. amabilis
	A. cilicica
	A. fargesii
	A. fraseri 'Prostrata'
	A. lasiocarpa 'Compacta'
	A. procera 'Glauca'
	A. veitchii
	A. veitchii var. *olivacea*
A. concolor	*A. cephalonica*
	A. concolor 'Violacea'
A. firma	*A. alba*
	A. concolor 'Conica'
	A. concolor 'Violacea'
	A. firma
	A. homolepis
	A. koreana
	A. lasiocarpa 'Compacta'

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ACTINOSTROBUS: **Actinostrobus**

This genus contains two species of shrubs. They are related to *Callitris* and are native to Western Australia. The unopened cones of these evergreens remain on the plants for a long period. They may be picked and allowed to dry, after which the scales will open, releasing the seed. Seed germinates readily without special treatment. Cuttings should be taken from the tips of vigorously growing twigs. Mist is recommended, or the bench may be covered with a polyethylene propagating structure. Without hormone treatment, rooting takes six to nine months.

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AGATHIS: **Kauri Pine**

Sixteen to twenty species of large evergreen trees with massive trunks make up this genus, which is native from the Malay Peninsula to New Zealand. There is little information on propagation. Seed appears to germinate readily, but must be sown immediately upon collection. Many of the seeds are infertile. Adventitious shoots from the stumps of felled trees exhibit physiological juvenility and may be used as cuttings.

As with *Actinostrobus*, cuttings should be taken from the tips of vigorously growing twigs. They should be rooted under mist or polyethylene plastic. In the absence of hormone treatment, rooting takes six to nine months.

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ARAUCARIA: **Araucaria**

There are ten or twelve species of *Araucaria*, some natives of South America, others of Australia and the Pacific Islands. These plants are most commonly propagated by sexual means.

Sexual Propagation

Male and female cones of *Araucaria* are borne on the same tree. The female cone is ovoid and composed of wedge-shaped scales that break apart at maturity to release winged seeds. The seed is produced at irregular intervals and much of it is infertile. It deteriorates quickly and should be sown immediately upon collection. Germination is usually good, but growth of seedlings is slow.

Vegetative Propagation

Rooted cuttings of *Araucaria heterophylla* develop into more desirable trees than do seedlings, as they are slower growing and more compact in habit. Only vertical shoots, however, are suitable for cuttings; shoots from branches root, but they lead to misshapen plants. Though *Araucaria* ordinarily produces only one vertical shoot, its leader, it is possible to produce numerous suitable cuttings from one stock plant. A seedling is grown until it has five or six branch whorls, and its leader is removed and rooted. Erect shoots soon arise from the axils at the top whorl of branches and can be removed and rooted. The plant is then cut back to the next whorl of branches, where a second set of vertical shoots develops. This process may be continued until shoots have been taken from the axils of the last whorl of branches.

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U.S.D.A. Forest Service. Seeds of Woody Plants in the United States. Agric. Handbook No. 450. Washington. 1974. pp. 223–225.

ATHROTAXIS: **Tasmanian Cedar**

This genus of three evergreen trees, native to the mountains of Tasmania, is apparently related to *Cryptomeria*. *Athrotaxis* species are commonly propagated by both seeds and cuttings. Seeds should be sown in February or March. Cuttings should be taken in late spring or early summer from the tips of vigorously growing twigs, and inserted in sandy soil under mist or in a polyethylene propagating structure.

Rooting, without hormone treatment, takes six to nine months. Cuttings of *Athrotaxis selaginoides* form callus readily, but root poorly. *Athrotaxis* has been grafted successfully on stocks of *Cryptomeria japonica*.

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AUSTROCEDRUS: **Austrocedrus**

This monotypic genus of variable sized trees often has been included in *Libocedrus* and is native to Western Argentina and Chile.

Austrocedrus chilensis. "Cuttings of ripened wood (brown at base) with heel inserted in 75% peat, 25% sand mixture, in mist unit with medium temperature of 65° — 75° F, rooted 50% successfully. Cuttings similarly treated in February were a total failure." D.M.H.

CALLITRIS: **Cypress Pine**

An evergreen genus of about twenty species of trees and shrubs, *Callitris* are native to Australia and Tasmania. They are best propagated from seed, which germinates readily. It is borne in a globular cone composed of six to eight woody scales arranged in one whorl. The cone remains on the tree for a long period and can be collected at any time. When dry, it opens to release the dark brown winged seeds. Many of the seeds are infertile.

Cuttings taken from the tips of vigorously growing twigs of *Callitris oblonga* and *C. tasmanica* have been rooted. Mist is recommended, or the propagating bench may be covered with plastic. Rooting without hormone treatment takes six to nine months.

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CALOCEDRUS: Incense-cedar

There are three species of evergreen trees in the genus *Calocedrus* native to North America (*C. decurrens*), Formosa (*C. formosana*) and China (*C. macrolepsis*) respectively. They were formerly included in the genus *Libocedrus* but probably are more closely related to *Thuja*.

Incense-cedar is best reproduced from seeds, though cutting and grafting propagation are possible.

Sexual Propagation

Male and female cones are borne separately at the tips of twigs on the same tree. Oblong, pendant female cones mature in one season, but remain attached to the branch until the following year. They are composed of six paired, hard flat scales. Each of the two middle scales bears two winged seeds which are shed in late summer and early fall. Crops are not produced regularly, but when they do occur they are heavy. The seeds have a broad wing and can be carried great distances by air currents. Cones are ready for collection when they turn a light reddish-brown. They can be separated from the seed by screening. Under ordinary storage conditions, seed loses viability rapidly, but storage of dry seed in sealed refrigerated containers prolongs its life somewhat. A fair percentage of incense-cedar seed germinates without pretreatment, but a two- to three-month period of cold stratification greatly improves and unifies germination.

Asexual Propagation

Partially hardened cuttings of *Calocedrus* may be taken in August. Scions consisting of the current year's growth can also be grafted at this time. A side graft should be used on understocks of *Thuja occidentalis* established at least one growing season ahead of their use.

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CEDRUS: **Cedar**

Members of this genus are found in North Africa and Asia. There are four species, all large evergreen trees. Cedars are generally propagated by seed.

Sexual Propagation

Male and female cones of *Cedrus* are borne on the same tree. The mature cones are large, light brown, and held upright on the tree branches by short woody stalks. They are composed of numerous thin woody scales, each with two seeds at its base. The seeds are roughly triangular in shape and have a broad papery wing that aids in wind dispersal when the cones shatter to release seeds in autumn of their second or third year. In the Northeast, cones are ripe enough for collection by August and are cut free from the branches before they crumble apart. After they dry, scales and seeds break away from the central woody axis and must be separated from each other. Since they are similar in size, screening is impractical. Small quantities of seed may be hand-cleaned, while large quantities must be separated from the scales by fanning techniques. The seed is fragile and must be handled gently. It need not be dewinged. *Cedrus* seeds lose their viability after several months if kept at room temperature, but seeds dried for a week or two, then placed in sealed polyethylene bags and stored in a refrigerator at 40° F have germinated in high percentages after two years.

Extremely variable degrees of dormancy may be observed within a single lot of *Cedrus* seeds. If they are not provided with a period of cold stratification, they germinate erratically over a period of several months. Seeds stratified for one month at 40° F germinate in about two weeks, while those stratified for two months germinate in four to seven days. After three months of stratification, germination takes place in the refrigerator. Because cedar seedlings are particularly susceptible to damping-off organisms, it is advisable to germinate them in the lengthening days of late winter or early spring. Dry seed should be placed in cold storage until about two months before the desired germination date, then treated to a period of cold stratification and sown.

Asexual Propagation

Cutting

Cedrus libani and *C. atlantica* cuttings have been rooted, but usually in small percentages. However, cuttings taken in October from some clones of *C. deodara* have rooted well. The table below shows four treatments which led to high rooting percentages in *Cedrus deodara* 'Kingsville'. Cuttings were placed under polyethylene film with bottom heat at 75° F. After one growing season, the rooted cuttings were 22 inches tall. *C. deodara* 'Kashmir' and an unnamed clone each showed similar responses.

Cedrus deodara 'Kingsville'

Treatment	Number of Cuttings	% of rooting
Powder Formulations		
8 mg IBA plus 150 mg Thiram per gm of talc	50	90
Liquid Formulations (5-second dip)		
5 mg IBA plus 5 mg NAA per gm	50	84
2.5 mg IBA plus 2.5 mg NAA per gm	50	64
10 mg IBA per gm	50	80
Control — no treatment	50	88

Grafting

Cedrus can be propagated by side-grafting seedling understocks in January or February, when roots begin active growth. The understocks are potted one growing season in advance of their use and provided with a cold period before being brought into the greenhouse. *Cedrus libani, C. atlantica* and *C. deodara* all are compatible and can be used as understocks, but *C. deodara* is preferred, since it has the most compact and fibrous root system.

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* This cultivar later was determined to be *Cedrus deodara* 'Kingsville'.

CEPHALOTAXUS: **Plum-yew**

All five species of *Cephalotaxus* are native to Asia. They are evergreen trees or shrubs and may be propagated by seeds or cuttings. Male and female cones of the genus are borne on separate trees. The fleshy cones are about 2½ centimeters long, each bearing one or two seeds. They ripen during their second season.

Softwood cuttings taken from the tips of *Cephalotaxus harringtonia* twigs in late June have been rooted under intermittent mist, after treatment with a powder formulation of 2, 4, 5-T and NAA. In five instances, cuttings taken in autumn and treated with 8 mg IBA in a gram of talc plus the fungicide Thiram have rooted in high percentages. Seeds stratified for three months at 40° F produced 70% germination in ten days.

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CHAMAECYPARIS: **False-cypress**

There are six species of false-cypress: three native to North America, three to East Asia. Since there are a large number of recognized cultivars, *Chamaecyparis* is usually propagated asexually.

Sexual Propagation

Male and female cones are borne separately on the same plant. The female cones are small and spherical, composed of six to twelve scales. They open in autumn of the first year to release from one to five winged seeds per scale for dispersal by the wind. The empty cones may remain on the tree through the winter. Seeds are small, slightly flattened and oblong, with two narrow longitudinal wings. When cones turn from yellow-green to pale brown, they are ready for collection and drying. Seeds can be separated from the dry cones by screening, but they are easily damaged and should not be dewinged. They lose their viability quickly unless stored in sealed containers at 40° F following collection.

Some species of *Chamaecyparis* exhibit embryo dormancy. There is also variation between different lots of the same species, with

dormancy apparently influenced by the geographic origin of the seed. In all cases, a two- or three-month period of cold stratification is of benefit, leading to rapid germination and a uniform stand of seedlings. *Chamaecyparis* is particularly susceptible to damping-off and germination during the lengthening days of late winter or early spring increases chances of survival. If necessary, stratification can be extended beyond the three-month period so that the seeds can be sown in late winter or early spring.

Asexual Propagation

Cutting

Hardwood cuttings of most *Chamaecyparis* cultivars, taken any time from September to April, root in high percentages. Cuttings of normal size may be taken from most *Chamaecyparis*. However, some cultivars produce less than a ½ inch of growth in a single year and must be propagated from extremely small cuttings. Cuttings may be treated with a variety of commercially available rooting compounds. Preparations containing 3 mg IBA per gram of talc have been used. *Chamaecyparis pisifera, C. thyoides* and *C. lawsoniana* root in approximately three months. In an English experience, extending the day length by four hours with artificial lighting increased the speed and percentage of rooting.

In general, *Chamaecyparis obtusa* and *C. nootkatensis* cultivars are more difficult to root than those of other species. Cuttings taken in late winter or early spring appear to root more easily than those taken in fall or midwinter. Growth-promoting materials containing 8 mg IBA per gram of talc have been used for these hard-to-root taxa, and in recent years, materials containing combinations of IBA plus NAA have been used effectively. Rooting time for *Chamaecyparis obtusa* cultivars varies widely, and rooting percentages are sometimes low.

Grafting

Grafting has been an accepted way of propagating the more difficult-to-root taxa of *Chamaecyparis*. In the nursery trade, *C. obtusa, C. lawsoniana*, and *C. nootkatensis* are frequently grafted on *Thuja orientalis* or *Chamaecyparis lawsoniana* seedlings. Rooted cuttings of *Chamaecyparis pisifera* 'Boulevard' are also satisfactory understocks for these taxa. 'Boulevard' is a juvenile form and can be rooted easily. Cuttings inserted in October or November are ready for veneer- or side-grafting by January or February. After grafting, plants are plunged in peat to above the level of the graft union.

Chamaecyparis lawsoniana seedlings have also been used for special purposes such as the production of tall rootstocks for grafting standard plants.

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U.S.D.A. Forest Service. Seeds of Woody Plants in the United States. Agric. Handbook No. 450. Washington. 1974. pp. 316–320.

CRYPTOMERIA: **Cryptomeria**

Cryptomeria japonica, native to China and Japan, is the only species in this genus. *Cryptomeria* may be propagated by seed, which has a reputation for germinating poorly. A sowing rate based on 30% germination to obtain a proper seedling density has been reported from Japan. Sixty to ninety days of cold stratification at about 40° F is recommended.

Cultivars of *Cryptomeria* are usually propagated by grafting, using the species as understock. However, cuttings of many cultivars have rooted in high percentages. Among these are 'Bandai-Sugi', 'Compressa', 'Cristata', 'Elegans', 'Nana', 'Spiralis', 'Spiralis Falcata', and 'Vilmoriniana'. All were taken in autumn and propagated in polyethylene structures. Root inducing material containing 8 mg IBA per gram of talc plus the fungicide Thiram at the rate of 150 mg has proven satisfactory for rooting *Cryptomeria* cuttings.

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CUNNINGHAMIA: **China-fir.**

The genus *Cunninghamia* contains three species of evergreen trees related to *Taxodium* and *Sequoia* and native to China and Formosa. China-fir can be propagated by both seeds and cuttings. Male and female cones are borne on the same tree. The cones are round

with leathery scales, each bearing three seeds. Following release of seeds, the cone persists on the tree. Hardwood cuttings taken in autumn and treated with 8 mg IBA plus a fungicide root in high percentages. However, they tend to retain the characteristics of a branch, resulting in horizontal growth.

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CUPRESSUS: Cypress

This is a genus of about twenty species. Cypress are widely distributed in the warmer areas of the Northern Hemisphere. The best known species, *Cupressus sempervirens*, is widespread in the Mediterranean region.

Cypress may be propagated by seeds, cuttings, and grafts.

Sexual Propagation

Male and female cones are borne on the same tree. Female cones, small and globe-like, ripen their second season and consist of six to twelve scales, each having numerous winged seeds. Many cones remain closed on the tree for long periods of time. They can be collected as soon as they turn dark brown; the seeds are separated by screening. Seeds can be held from one to four years with little loss of viability if refrigerated in sealed containers. A period of cold stratification, usually about two months, appears to improve germination.

Asexual Propagation

Cupressus cultivars can be increased by cuttings taken in July and August. *Cupressus macrocarpa* cuttings responded well to treatment with IBA prior to insertion. Although a number of authors recommend taking cuttings between October and February, we have not had much success (± 10%) at the Arnold Arboretum with cuttings taken at this period.

Scions from *Cupressus* cultivars can be veneer-grafted on two-year understocks of the parent species. Because the foliage is especially susceptible to mildew, an effort should be made to keep the foliage dry when caring for newly grafted plants.

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× *CUPRESSOCYPARIS:* **Leland Cypress**

× *Cupressocyparis leylandii* is an intergeneric hybrid between *Cupressus macrocarpa* and *Chamaecyparis nootkatensis* which originated spontaneously at Leighton Hall, Welshpool, England in 1888.

The propagation of × *Cupressocyparis* is similar to that of the easily propagated forms of *Chamaecyparis*. Cuttings taken in autumn and winter have rooted in high percentages when treated with 8 mg of IBA in a gram of talc combined with a fungicide.

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DACRYDIUM: **Dacrydium**

Dacrydium is a genus of about twenty species of evergreen trees related to *Podocarpus*. They are distributed from the Malay Peninsula and Indo-China south to Australia, Tasmania and New Zealand, and one species, *D. fonkii*, is native to Chile.

Dacrydium may be propagated by cuttings taken from the tips of vigorously growing twigs and rooted under mist or plastic. Without benefit of hormone treatment, root initiation takes from six to nine months.

Dacrydium cupressinum and *D. laxifolium*

"Heel cuttings, semi-ripe at various times during the summer, rooted between 35%–75% successfully. August/September appears to be the optimum period. A rooting medium of 75% peat/ 25% sand has been used. Similarly treated cuttings taken in December were a total failure." D.M.H.

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DISELMA: **Diselma**

A single species of evergreen bush, or small tree, related to *Fitzroya*, *Diselma archeri* is native to Tasmania.

Cuttings of this plant may be taken from the tips of vigorously growing twigs. Mist is recommended, or the bench may be covered with plastic. Rooting, without hormone treatment, takes six to nine months.

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EPHEDRA: **Ephedra**

A genus of about forty species of leafless shrubs, *Ephedra* is native in warm dry areas in both North America and Eurasia.

Seeds germinate readily without special treatment.

Cuttings are reputed to root readily. Layering seems to be common in nature.

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FITZROYA: **Fitzroya**

Fitzroya is a monotypic genus of large evergreen trees related to *Callitris*, and native to Chile and western Argentina. It can be propagated by seeds and cuttings, though it is reported that most cultivated trees bear only female cones and produce infertile seed.

"Cuttings of ripened wood (brown at base) with a heel, inserted in 75% peat/ 25% sand, under mist, with the medium at 65°–75° F, rooted 75% when taken in mid-August. Cuttings taken in mid-November were a total failure." D.M.H.

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GINKGO: **Maidenhair Tree**

Ginkgo is a monotypic genus unknown in the wild, but preserved for many years in the temple gardens of China. It is best propagated vegetatively as seedlings lead to plants that vary widely in growth rate and tree shape. Female plants are undesirable because of malodorous fruits. Therefore desirable clones are propagated asexually.

Sexual Propagation

Male and female reproductive structures are produced on separate trees. It takes twenty years or more for seedlings to develop their first cones and then the crops are not borne regularly. Some trees appear to be alternate bearers. The buff-colored seed, with a hard seedcoat, is enclosed within a fleshy pulp, and is mature in autumn of its first year. Its fleshy outer layer would suggest natural dispersal by birds or animals, but none is known to feed on it. Since the ginkgo (*Ginkgo biloba*) is a primitive tree, its vector quite possibly is extinct. For this reason, seeds are never carried far from the parent plant.

Ginkgo seed is ready for collection in autumn about the same time the tree's leaves begin to fall. Seed can be cleaned by maceration and flotation techniques; gloves and protective clothing are recommended since there have been reports of illness among workers processing ginkgo seeds. The seed loses viability quickly if stored at room temperatures. It should be placed in sealed containers and held at 40° F. to prolong viability. Newly collected ginkgo seed requires a period of after-ripening, since it shows no embryo. When sown out-of-doors immediately following collection, the seeds develop embryos and germinate in the spring. In one experience with seed germinated in the greenhouse, untreated seed germinated erratically over a period of eighty-one days. Seven tests using cold pretreatment for various periods, and tests combining warm and cold pretreatment failed to unify germination.

Asexual Propagation

Cutting

Ginkgo cuttings can be taken in late June from the current season's growth as the shoots become woody. When treated with a rooting compound containing 8 mg IBA and 15 mg Thiram per gram of talc, and placed either under mist or polyethylene plastic, rooting occurs in seven to eight weeks. Ginkgo trees have a rather unusual growth pattern. Terminal buds lead to long shoots while lateral spurs generally produce short shoots. Since long shoots are found mainly at the branch tips of ginkgo trees, it is difficult to obtain long cuttings in quantity. Experiments have shown that cuttings made from short lateral spurs will root as well as those made from long

shoots. Rooted spurs produced long shoots their second summer after a period of dormancy. By their second autumn, the plants were about 2 feet tall.

Grafting and Budding

Ginkgo trees are frequently grafted by commercial nurserymen. Scions can be taken in January and February and grafted on potted understocks using a whip-and-tongue graft.

Ginkgo may be shield-budded during the growing season when the bark separates easily from the wood. This technique is used to propagate ginkgo standards. Buds, usually from the cultivar 'Pendula', are inserted high on a 6- to 8-foot standard rootstock.

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JUNIPERUS: Juniper

About sixty species of trees and shrubs, almost all native to the Northern Hemisphere, make up this evergreen genus. Junipers are commonly propagated both sexually and asexually.

Sexual Propagation

Male and female cones of *Juniperus* are borne on the same, or occasionally different, plants. The mature female cone is fleshy, containing from one to twelve brown seeds. Depending on the species, it is light or dark green. When ripened in autumn of its first, second or third year, it turns to blue, red-brown or black, with a distinct bloom. Cones should be collected as soon as possible after ripening, since they are taken quickly by the birds. *Juniperus ashei* and *J. virginiana* cones ripen in autumn of their first year; those of *J. occidentalis, J. deppreana, J. scopulorum, J. osteosperma, J. recurva* and *J. rigida* in autumn of their second year; and those of *J. communis* and *J. monosperma* in autumn of their third year following pollination. *Juniperus sabina* ripens in fall of the first season or spring of the second. Seed may be cleaned by macerating the cones in a modified blender and floating the pulp and void seeds away.

All juniper seeds exhibit embryo dormancy and require a three-month period of cold stratification to induce germination. Many

benefit from at least a five-month period of warm stratification prior to cold stratification in order to overcome impermeable seed coats.

Asexual Propagation

Cutting

Junipers exhibit extremely variable rooting behavior, depending on the species. *Juniperus communis, J. conferta, J. horizontalis* and *J. sabina* are easily rooted from cuttings taken in October, November or December. Summer cuttings may be rooted if taken back to mature wood of the previous year's growth. Root-inducing materials are not necessary, though treatment with a compound containing 3 mg IBA per gram of talc may hasten root initiation and encourage more extensive root development. Cuttings root in eight to ten weeks.

Juniperus procumbens, J. pseudosabina, J. recurva and *J. squamata*, and most of their cultivars, root in worthwhile percentages. Cuttings taken in November and December have responded well when treated with a material containing 8 mg IBA per gram of talc and wounded on one side. Rooting occurs in about three months.

In one experience, cuttings of *Juniperus distans*, taken in November and treated with a compound containing 8 mg IBA per gram of talc, rooted in four months.

Some of the variants of *Juniperus chinensis* are grafted, but many can be rooted successfully. *Juniperus chinensis* 'Hetzii' roots so easily that it is frequently used as an understock for other junipers. Cuttings may be taken in autumn and treated with a rooting material containing 3 mg IBA per gram of talc. More difficult-to-root cultivars may be treated with a material containing 8 mg per gram of talc. Rooting occurs in three to four months.

The following cultivars of *Juniperus chinensis* have been rooted commercially: 'Armstrongii', 'Blue Cloud', 'Columnaris', 'Fairview', 'Globosa Cinerea', 'Hetzii', 'Kaizuka', 'Kalley', 'Keteleeri', 'Obelisk', 'Old Gold', 'Olympia', 'Pfitzeriana Aurea', 'Pfitzeriana Compacta', 'Pfitzeriana Glauca', 'Plumosa Aurea', 'Pyramidalis', 'Richeson', 'San Jose', 'Shoosmith', var sargentii, var. sargentii 'Glauca', 'Spartan', 'Variegata'.

Juniperus virginiana is considered difficult to root and is usually propagated by seed or grafting. Cuttings of four cultivars, *Juniperus virginiana* 'Burkii', 'Nana Compacta', 'Silver Spreader', and 'Skyrocket' were taken in early winter and treated with a rooting compound containing 8 mg IBA per gram of talc. All rooted well but did so slowly. 'Burkii' rooted in eight months; 'Skyrocket' in six months. Another *Juniperus virginiana* cultivar, 'Kosteri', rooted well when treated with IBA and NAA at 2.5 mg per gram, or with IBA at 8 mg per gram of talc.

Grafting

Many cultivars of *Juniperus chinensis, J. scopulorum, J. squamata* and *J. virginiana* are difficult to root in practical percentages and usually are grafted. *Juniperus rigida* and *J. turkestanica* do not root and are always grafted. *Juniperus virginiana* and *J. chinensis* 'Hetzii' are compatible with all junipers and are commonly used as understocks. Some *Juniperus virginiana* varieties have been grafted on *J. horizontalis* 'Plumosa' and *J. sabina* understock as well.

Scions taken in December, January and February can be side-grafted on established understock.

Cuttings to be used as understocks will be ready by January if inserted in September or October.

The following cultivars of *Juniperus* are commonly grafted: *Juniperus chinensis* 'Ames', 'Blaauw', 'Iowa'; *J. scopulorum* 'Blue Heaven', 'Moffetii', 'Pathfinder', 'Sutherland', 'Tabletop', 'Welchii'; *J. virginiana* 'Burkii', 'Canaertii', 'Cupressifolia', 'Glauca', 'Hillii', 'Manhattan Blue'.

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LARIX: Larch

Larches are found in the cold regions of the Northern Hemisphere. There are about ten species in the genus.

Propagation of the larches is by seed, except for their cultivars which are grafted. Male and female cones are borne separately on the same tree. The female cone is erect, round-to-oblong, maturing during autumn of its first year. Seeds are dispersed in autumn or spring following cone-ripening, but the empty cones remain on the tree following dispersal for an indefinite period of time. After collection, seed can be separated from cones by screening and then stored dry in sealed containers at 40° F. Larch seed germinates fairly well without pretreatment, but benefits from stratification for one or two months prior to sowing in March or April.

Cuttings of *Larix* are considered difficult to root, though softwood cuttings of *L. sibirica*, *L. laricina*, and *L. griffithii* have rooted in small percentages when treated with a rooting compound containing IBA at 8 mg per gram of talc. Cultivars can be grafted on established understocks of *L. decidua* in winter. A whip-and-tongue graft can be used.

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METASEQUOIA: **Dawn Redwood**

Metasequoia is a monotypic genus, introduced to the West from Mainland China in 1947 when an expedition sponsored by the Arnold Arboretum procured seed from a stand of trees in the Shuisapa Valley. Shortly after, diplomatic relations between the United States and China were severed and dawn redwood (*Metasequoia glyptostroboides*) seed could no longer be obtained. It is not known whether the trees in the Shuisapa Valley have survived. Until recently, when trees raised from the original 1947 seed lots began bearing fertile seed, *Metasequoia* was propagated exclusively by asexual techniques.

Sexual Propagation

Male and female cones of *Metasequoia* are borne on the same tree. The female cones are small, pendulous and egg-shaped, with numerous thick scales which, upon ripening in autumn of their first year, release seed for wind dispersal. The empty cones persist on the trees for at least part of the first winter. Closed cones are ready for collection by late October, about the time the leaves fall. The seeds of *Metasequoia* are small and flattened, entirely surrounded by two, broad convergent wings. They are easily extracted from the cones by screening.

Little information is available on the storage and germination of *Metasequoia* seeds. Seed from the original 1947 shipment was sown immediately upon receipt at the Arnold Arboretum with no pretreatment. It germinated, but there are no records of germination percentages or times. A small number of the original seeds were saved and attempts were made to germinate them in 1950; this effort failed.

Asexual Propagation

Excellent rooting can be expected from both hard- and softwood cuttings of *Metasequoia*. Hardwood cuttings have been successfully rooted in November or December; softwood cuttings in late June or early July. All can be treated with a root-inducing material containing 3 mg IBA per gram of talc. An open greenhouse bench with bottom heat is suitable for rooting hardwood cuttings. Softwood cuttings should be placed under mist or in polyethylene structures. The approximate rooting time for both is seven to eight weeks.

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MICROBIOTA: **Microbiota**

Microbiota decussata, the only species in its genus, is a small evergreen shrub, related to *Juniperus* and native to southeastern Siberia.

"Cuttings of ripened wood (brown at base) with a heel, inserted in 75% peat/ 25% sand, under mist, with the medium at 65°–75° F rooted 50% when taken in mid-June." D.M.H.

MICROCACHRYS: **Microcachrys**

This monotypic genus of evergreen shrubs is related to *Podocarpus* and native to Tasmania.

Cuttings may be taken from the tips of vigorously growing twigs and rooted under mist or polyethylene. Rooting without hormone treatment takes six to nine months.

"Cuttings of ripened (and frosted) wood (brown at base) with a heel inserted in 75% peat/ 25% sand, under mist, with the medium at 65°–75° F, rooted 60% in 3 months, when taken in February." D.M.H.

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MICROSTROBUS: **Microstrobus**

This genus contains two species of evergreen shrubs and is related to *Dacrydium*, *Diselma*, and *Microcachrys*. One species is native to Tasmania; the other, to New South Wales.

These plants may be propagated from cuttings. However, while callus forms freely, root production often is not good. Cuttings may be taken from the tips of vigorously growing twigs. Mist is recommended, or the bench may be covered with plastic. Without hormone treatment, rooting takes six to nine months.

M. fitzgeraldii

"Ripe cuttings taken in September rooted 50%. It is easy to establish." D.M.H.

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PAPUACEDRUS: **Papuacedrus**

Papuacedrus is a genus of three species endemic to New Guinea; all have been transferred from *Libocedrus* by H. L. Li. Plants are monoecious with ovoid female cones of four scales; the outer two sterile, and the inner two each with two seeds.

Seeds of *Papuacedrus papuana* sown one month after collection germinated in five weeks without pretreatment. Seedlings were established without difficulty.

Subsequent propagation of the seedling plants was by cuttings treated with 8 mg of IBA and 150 mg of Thiram per gram of talc. High rooting percentages were obtained in four months under mist or in a polyethylene propagating structure.

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PHYLLOCLADUS: **Phyllocladus**

Six species of evergreen trees or shrubs native from the Philippines to Tasmania and New Zealand comprise this genus.

Cuttings may be taken from the tips of vigorously growing twigs. Mist is recommended, or a polyethylene propagating structure may be used. Rooting, without hormone treatment, takes six to nine months.

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PICEA: **Spruce**

About forty species, native to the cold and temperate regions of the Northern Hemisphere, make up this evergreen genus. Except for its cultivars, *Picea* is usually propagated by seed.

Sexual Propagation

Male and female cones are borne on the same trees. The female cone is egg-shaped and hangs from twigs of the previous year's growth. Its scales are thin and sometimes pointed, each supporting two, oblong winged seeds which are released by most species for dispersal by the wind during autumn of their first year. (The cones of *Picea abies* open over a long period of time, releasing their seeds from autumn to early spring. *Picea mariana* cones release their seeds over a period of two to three years.) Cones should be collected in the fall, after they turn brown but before they open. Once the cones have opened, seeds may be separated from them by screening. When held under ordinary storage conditions at room temperature, *Picea* seeds retain their viability for several years. In sealed containers held at 40° F, they may retain viability for up to ten years.

Dormancy of spruce seed varies with the species and seed lot. Most lots show embryo dormancy and benefit from a three-month period of cold stratification at 40° F. *Picea mariana* and *P. sitchensis* germinate in fair percentages without any pretreatment, but a period of cold unifies and shortens the time required for germination.

Asexual Propagation

Cutting

Cuttings of numerous spruce cultivars showing dwarf characteristics can be rooted in worthwhile percentages. Dwarf and abnormal forms of *Picea abies, P. glauca, P. mariana, P. omorika, P. orientalis* and *P. pungens* have been rooted from cuttings consisting of two or three growth flushes taken in October, November and December.

They were treated with a rooting compound containing 8 mg IBA per gram of talc, plus a fungicide, and rooted in about three months.

In one test involving *Picea pungens*, softwood cuttings were taken when new growth was 2 to 4 inches long and terminal buds were starting to appear. The leading shoots proved more difficult to root than comparable wood on the six or so lateral growths immediately behind. All these cuttings were treated with a rooting compound containing 3 mg IBA per gram of talc and placed outdoors under mist. They rooted in high percentages and were ready to be potted by the end of September.

Grafting

There appears to be wide latitude in the selection of understock for clones of *Picea*, though many nurserymen consider *P. abies* to be the most satisfactory understock for all taxa. Scions can be taken in December, January or February and side-grafted on established understock potted one growing season in advance of use.

These graft combinations have survived for many years at the Arnold Arboretum.

Rootstock	Compatible Scion
Picea abies	*Picea abies*
	P. glauca
	P. jezoensis
	P. mariana
	P. orientalis
	P. pungens
	P. purpurea
	P. rubens
P. glauca	*P. abies*
	P. aurantiaca
	P. mariana
P. omorika	*P. obovata*
P. pungens	*P. abies*
	P. aurantiaca
	P. pungens

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PILGERODENDRON: **Pilgerodendron**

A monotypic genus of evergreen tree, *Pilgerodendron* is related to *Libocedrus* and *Calocedrus*, and is native to Chile.

Pilgerodendron uviferum

"Semi-ripe cuttings taken in mid-November rooted 65%, but were not easy to establish." D.M.H.

PINUS: **Pine**

The genus *Pinus*, with about ninety species, is one of the most widely distributed genera of trees native to the Northern Hemisphere. It ranges from the Arctic Circle to below the Equator at one point in Sumatra.

Sexual Propagation

Male and female cones of the pines are borne separately on the same tree. Pollination takes place during late spring and early summer, but fertilization is delayed until the following spring. The resulting cone is quite woody and is composed of thick, closely packed scales. These vary greatly in size and shape, depending on the species. Cones of most pines mature in autumn of their second year, opening to release two seeds per scale for dispersal by the wind. Serotinous cones of the so-called "fire" pines (*Pinus attenuata, P. radiata, P. contorta* var. *latifolia, P. muricata* and *P. pungens*) remain on the tree for many years after they mature, dispersing their seeds only following the intense heat of a forest fire. Cones of other pines, such as *P. banksiana* vary in behavior. Some open immediately upon maturity while others are serotinous.

Pine cones should be collected in late summer or autumn before they open and after they begin to turn brown. Seed can be separated from open cones by screening. Longevity in storage varies enormously with the species. Fire pine seed remains viable in cones on the tree for long periods, while seed of other species is more perishable and may deteriorate within a year of collection if not held under controlled storage conditions. Its viability is extended by storing it dry in sealed containers at 40° F.

The flotation technique for separating viable from non-viable seed must be modified for some pine species. *Pinus bungeana* and *P. aristata* seeds, for example, have an air chamber which makes even sound seed buoyant for about a day after it is placed in a column of water. By the second day, separation has occurred and sound seed has sunk to the bottom while void seed remains afloat.

Seed of many pine species benefits from a period of cold stratification, though some germinates in high percentages when sown directly. Germination behavior varies widely depending on the species and seed lot. *Pinus banksiana, P. bungeana* and *P. pungens* require no cold period, though germination of seed that has been stored for long periods may be unified by stratification. *Pinus aristata, P. cembroides* var. *monophylla* and *P. virginiana* should be stratified at 40° F for an eight-month period. *Pinus strobus* and *P. taeda* require two months of stratification, and *P. armandii, P. balfouriana, P. flexilis* and *P. peuce* three months. Four months should be allowed for *P. albicaulis* and *P. monticola; P. cembra* may require up to nine months. In the event that the cold requirement of seeds is not known, a three-month cold treatment is recommended; it will do no

harm to those seeds not requiring it. Some pine seed (*Pinus cembra*, *P. albicaulis*, *P. flexilis*, *P. cembroides* var. *monophylla* and *P. monticola*) benefits from acid scarification.

Asexual Propagation

Grafting

Rooting of pine cuttings is difficult, and asexual propagation is usually accomplished by grafting.

As a simple rule, the number of needles per fascicle can be used to gauge grafting compatibility. Two-needled pines are generally compatible with other two-needled pines; the same is true for three-needled species. Five-needled pines are *always* compatible with other five-needled pines. There are, however, exceptions to this general rule. For example, *Pinus bungeana* and *P. rigida*, both three-needled pines, are not compatible. *Pinus bungeana* has proven compatible with a five-needled pine, *P. strobus*. *Pinus rigida* cultivars should be grafted on their parent species. A more useful rule may be that pines in the same subgenus are apt to be compatible. Classification of pines may be determined by checking a standard reference.

These graft combinations have survived a significant number of years at the Arnold Arboretum.

Rootstocks	Compatible Scions
Pinus nigra	*Pinus densiflora*
	P. heldreichii
	P. nigra varieties and cultivars
Pinus resinosa	*Pinus densiflora*
	P. heldreichii
	P. heldreichii leucodermis
	P. nigra caramanica
	P. ponderosa 'Pendula'
	P. resinosa cultivars
Pinus strobus	*Pinus aristata*
	P. ayacahuite
	P. bungeana
	P. cembra
	P. cembra 'Stricta'
	P. cembroides
	P. flexilis
	P. holfordiana
	P. hunnewelliana
	P. koraiensis
	P. parviflora varieties and cultivars
	P. peuce

P. pumila
P. strobus varieties and cultivars
P. wallichiana
P. wallichiana zebrina

Pinus sylvestris
Pinus densiflora
P. densiflora 'Globosa'
P. mugo
P. mugo rostrata
P. sylvestris varieties and cultivars

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PODOCARPUS: **Podocarpus**

The genus *Podocarpus* consists of about one hundred species of evergreen trees and shrubs widely distributed in warm regions of the Southern Hemisphere and tropical regions of the Northern Hemisphere. These broad-needled plants can be increased by seed or cuttings. The oval nut-like seed is borne at the top of a fleshy, often red-colored, stalk. Seed sown in late winter will germinate in good percentages, but slowly. Cuttings should be taken from terminal shoots of the current season's growth in late summer or early autumn. They should be inserted in a sandy medium in a polyethylene propagating structure or under mist.

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PSEUDOLARIX: **Golden-larch**

This monotypic deciduous genus is native to China and bears male and female cones on separate branches of the same tree. It can be propagated by seed. Cones are yellow-brown and rosette-like in form, composed of numerous woody triangular scales. The winged seeds are released to wind dispersal in late October when the cones shatter, about the same time the tree sheds its leaves. For propagating purposes cones should be collected just prior to this, in early or mid-October. Seeds and scales are somewhat similar in size but differ in weight. They can be separated by fanning techniques.

Golden-larch (*Pseudolarix amabilis*) seed loses viability quickly when kept in dry storage. However, seed stored in sealed containers at 40° F germinates well after one year. Seed sown without pretreatment germinates erratically, but a two-month period of cold stratification produces a uniform stand of seedlings in about ten days.

Asexual Propagation

Rooting of cuttings is not necessary since the plant grows readily from seed. Cultivars may be grafted using seedling understocks of the species.

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PSEUDOTSUGA: **Douglas-fir**

The five or six species of evergreen trees in this genus are native to North America, Japan and China. Douglas-fir can be increased by seeds, cuttings or grafts.

Sexual Propagation

Male and female cones are borne on the same tree, on branches of the previous year's growth. The female cone, brownish in color, bears two seeds per scale. Cones may be collected in August or September and air-dried. Seeds can be separated from cones by screening and fanned to remove chaff. Both *Pseudotsuga menziesii* and *P. macrocarpa* seeds have retained viability for four years when stored in sealed refrigerated containers. Embryo, and quite possibly seedcoat, dormancy inhibit germination of Douglas-fir seed. Germination rate, and in some cases germination percentage, are improved by stratifying the seeds for one to two months at 40° F. Seedlings transplant easily.

Asexual Propagation

Cuttings taken in late winter rooted in high percentages after treatment with IBA. Those taken in fall or early winter were less successful. The best cuttings were made from year-old wood of the past season's growth. In one instance rooted cuttings failed to develop a well-defined leader by their third season. Douglas-fir cultivars can be side-grafted in winter on established understock of the species.

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SAXEGOTHAEA: Prince Albert's Yew

Saxegothaea contains a single species of evergreen tree, distantly related to both *Podocarpus* and *Araucaria*. It is native to Southern Chile.

"Ripe cuttings (after frost) rooted 99% when inserted in mid-January, 3 months to root. Fairly easily established." D.M.H.

SCIADOPITYS: **Umbrella Pine**

Sciadopitys is a monotypic genus native to Japan. It may be propagated by seed or cuttings but is of extremely slow growth. Many years are required to produce plants of usable size.

Male and female cones are borne on the same tree. The woody female cone with thick scales ripens the second season. When sowing *Sciadopitys* seed, care must be taken to cover it no more than ¼ inch. *Sciadopitys* seed germinates erratically in three to four months. Efforts to shorten and unify germination by stratification have not been effective.

Cuttings taken from terminal growths in June or July root in fair percentages by mid-October. January cuttings, taken from lateral branches of the most recent year's growth on fifty-year-old trees, rooted in five months when treated with a compound containing NAA. April cuttings from the same trees rooted well in six months when treated with IBA at the rate of 8 mg in a gram of talc. Cuttings taken in April from seven-year-old trees and treated with IBA rooted well in eight months.

It has been said that rooted cuttings of *Sciadopitys* lead to trees of poor shape. To investigate this, seedlings and rooted cuttings were grown side by side in the Arnold Arboretum nursery. The seedlings exhibited variable growth rates and plant shapes, while the rooted cuttings duplicated the form of the tree from which they were taken.

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SEQUOIA: **Coast Redwood**

This evergreen tree is native to the Pacific coast of North America. A single species, *Sequoia sempervirens*, is recognized. Except for its cultivars, *Sequoia* is generally propagated by seed. Male and female cones are borne on the same tree. The small egg-shaped female cones mature at the end of their first season but may persist for many years after the seeds are released. Ripe seed is light brown and flattened.

It may be collected in October, as soon as the cones turn yellowish in color. Drying of cones takes ten to thirty days but may be hastened by heating them in a kiln or oven to about 120° F, after which seeds can be separated from cones by screening. Usually, a high percentage of non-viable seed is present. Sound seed should be stored in sealed containers at 40° F to preserve viability. The seed is ready to germinate soon after release, but germination percentage is often improved by a period of cold stratification. Following germination, young seedlings require more water than do most gymnosperm seedlings.

Both hardwood and softwood cuttings are reported to root well. *Sequoia* cultivars also may be grafted on established understock in winter using a whip-and-tongue graft.

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SEQUOIADENDRON: **Big-tree**

A monotypic evergreen tree, *Sequoiadendron giganteum*, native to California, makes up this genus. Big-tree is generally propagated by seed. Male and female cones are borne on the same tree. The egg-shaped female cones are pendulous and mature in two or more years, remaining attached to the branch following seed dispersal. The stalk that attaches each cone to its branch forms growth rings yearly. These can be used to indicate ripened cones, ready for collection. Cones having three or more rings are mature while those having fewer may not be ripened. Big-tree seeds germinate without pretreatment. The sowing should be determined by the percentage of sound seeds, usually quite low.

Asexual Propagation

Shoots that arise from burls on the trunks of *Sequoiadendron* exhibit juvenility and can be rooted from cuttings. Cultivars can be propagated by grafting, using the species as understock.

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TAIWANIA: Taiwania

A large evergreen tree, the monotypic genus *Taiwania* is native to Taiwan and related to *Cunninghamia*.

Cuttings taken in mid-September, with or without treatment with IBA, rooted 24–46% in 150–300 days.

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TAXODIUM: Bald-cypress

There are three species of deciduous trees in this genus. They are natives of southeastern North America and Mexico. Bald-cypress is commonly propagated by seed. Male and female cones are borne on the same tree. The female cones are small, round and purplish, ripening from late September to November of their first season. The cones bear large, triangular seeds, too heavy to be dispersed by the wind. Water carries them to wet sites along streams and rivers and plays an important part in germination under natural conditions. Freshly gathered seeds sown in autumn lead to a good germination in spring. In greenhouse situations, untreated seed germinates slowly and poorly without pretreatment. Stratification for ninety days at 40° F speeds and improves germination. However, at best only about one-third of the sound seed germinates.

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TAXUS: Yew

Eight species of evergreen trees and shrubs make up the genus *Taxus*. They are native to the northern hemisphere. Male and female cones of all yews except *Taxus canadensis* are borne on different plants. *Taxus canadensis* is monoecious. A single seed is surrounded by a fleshy cone scale that is open at the apex. It ripens early in autumn of its first year and must be collected immediately, since it otherwise is taken quickly by birds and squirrels. Following collection, seed may be separated from the flesh by maceration and flotation techniques.

Yew seed exhibits double dormancy and natural germination does not take place until the summer of its second year. Satisfactory ways of overcoming dormancy in greenhouse situations have not yet been developed. Seed coat impermeability does not appear to be a problem, since neither hot water nor acid treatments have improved germination. In some instances, small lots of seeds have responded to a five-month warm stratification period followed by three months at 40° F. Should seed fail to germinate within several months after this treatment, it can be given an additional three-month cold period. However, yews tend to hybridize freely and seeds from collections such as are found in arboreta cannot be relied upon to reproduce the plants from which they came.

Asexual Propagation

Cutting

Most *Taxus* cultivars may be rooted with ease, the cuttings being taken from August through March and treated with a root-inducing material which contains 3 mg IBA per gram of talc. Some cultivars root without benefit of any rooting compound, though root initiation may take longer. Rooting time varies with the clone. *Taxus cuspidata*, *T. canadensis* and *T.* × *media* usually root in two and one-half to three months. In general *T. baccata* is more difficult to root and often requires a longer period of time. A root-inducing material containing 8 mg IBA per gram of talc should be used when dealing with this species.

Taxus cuttings of large size, comprised of two or three years' growth, root well and produce plants of usable size quickly.

Grafting

Taxus clones difficult to root may be propagated by grafting on rooted cuttings. Any clone which roots easily and forms a good compact root system may be used as an understock. *Taxus cuspidata* 'Nana' and *T.* × *media* 'Hatfieldii' are both satisfactory. Cuttings inserted in October or November can be side-grafted by January or February. They should then be plunged in a mixture of peat and perlite to a depth which covers the graft union.

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THUJA: Arborvitae

There are six species of arbovitae: two natives of North America, the others of East Asia. This common genus is easily propagated both sexually and asexually.

Sexual Propagation

Male and female cones of the arborvitae are borne on the same plant. The small female cones are composed of from six to twenty thin leathery scales, each bearing two to five winged seeds. The cones ripen in early autumn, opening soon after to discharge seeds for wind dispersal. The cones should be collected as soon as they turn from yellow-green to light brown. Seeds can be separated from open cones by screening but should not be dewinged since they are easily damaged. At room temperature, *Thuja* seed loses viability quickly. To preserve it, the seed should be stored in a sealed container at 40° F.

Some lots of *Thuja* seed require pretreatment to remove inhibitors while others germinate as soon as they ripen. Variation within a seed lot is also found. To insure germination, all seed should be stratified at 40° F for a period of two months. Germination then occurs uniformly in approximately three weeks.

Asexual Propagation

Cutting

Thuja cuttings appear to root well when taken any time from September to March. They can be treated with a rooting compound containing 3 mg IBA per gram of talc, and placed on an open greenhouse bench or in polyethylene chambers.

Rooting occurs in two and one-half to three months.

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THUJOPSIS: **Hiba Arborvitae**

Plants raised from seed of this monotypic Japanese genus show considerable variation in habit and grow slowly for a period of years. Cuttings taken from erect shoots are the preferred method of propagagating Hiba arborvitae (*Thujopsis dolobrata*).

At the Arnold Arboretum, hardwood cuttings taken in November and January and treated with 4 mg IBA in a gram of talc plus a fungicide rooted at the rate of 100%.

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TORREYA: **Torreya**

The six evergreen species in this genus are native to North America and East Asia. *Torreya* is best propagated by seed. Male and female cones are borne separately on different trees. The mature female cones are drupe-like and oval, each containing a single seed with a woody outer coat. They ripen from August to September of their second season and can be collected from September to November. *Torreya* seeds germinate slowly without pretreatment. It is possible that a period of cold stratification would hasten germination.

Summer cuttings from short side shoots of *Torreya* have been rooted. In two instances, cuttings of *Torreya taxifolia* taken at the Arnold Arboretum in autumn and treated with IBA at the rate of 8 mg in a gram of talc rooted in four months.

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TSUGA: Hemlock

There are ten species of hemlock; some native to North America and others to Japan, China and the eastern Himalayas. Hemlock is commonly propagated by seed. There is, however, great genetic variation, particularly in Canadian hemlock (*Tsuga canadensis*), and many dwarf and abnormal cultivars have been selected. These must be propagated asexually.

Sexual Propagation

Male and female cones are borne on the same tree. The female cone is solitary, pendulous, and borne at the end of a lateral shoot from the previous year. The cones release winged seeds for wind dispersal, then persist on the tree until summer or autumn of the second year. They are ready for collection in autumn of their first year, when they turn from green to purplish brown. Two seeds are borne per scale; each brown, slightly flattened and with a paper-thin wing. They are easily separated from open cones by screening.

Most lots of hemlock seed show some embryo dormancy and require a period of cold stratification for satisfactory germination. Three months at 40° F is usually adequate. Germination time is approximately three weeks.

Asexual Propagation

Cutting

Hemlock cuttings consisting of two or more years' growth taken in October and November, wounded and treated to a five-second dip in a liquid formulation of IBA and NAA at 5 mg per gram each have rooted well. Placed either on an open greenhouse bench or under polyethylene chambers, cuttings can be expected to root in high percentages in four to five months. Cuttings may also be taken from December through April.

Grafting

In the past, it was customary to propagate all hemlock cultivars by grafting them on *Tsuga canadensis* understocks. Instances of incompatibility between hemlock cultivars and their species, overgrowth of the scion, and girdling, brought about by circling roots which developed on understocks established in small pots, led to failure of the grafted plants shortly after grafting or in subsequent years. Therefore, we now propagate these plants from cuttings. Were we to graft hemlocks, it would be done in January or February on established understocks. A side or veneer graft would be used.

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Tsuga canadensis *'Pendula'* (*Sargent weeping hemlock*). *Photo: H. Howard.*

APPENDIX

The products listed below are root-inducing materials which are commercially available.

Product	Manufacturer	Effective Ingredient
Hormodin #1	Merck Chemical Division	1 mg IBA/gm of talc
Hormodin #2	" " "	3 mg IBA/gm of talc
Hormodin #3	" " "	8 mg IBA/gm of talc
Hormo-Root "A"	Hortus Products Co.	1 mg IBA/gm of talc plus 150 mg Thiram
Hormo-Root "B"	" " "	4 mg IBA/gm of talc plus 150 mg Thiram
Hormo-Root "C"	" " "	8 mg IBA/gm of talc plus 150 mg Thiram
Rootone #10	Amchem Products Inc.	5 mg Naphthalene-acetamide/gm of talc
Rootone with Fungicide	" " "	.57 mg IBA plus .33 mg NAA plus .13 mg Naphthylace-tamide/gm of talc plus 40 mg Thiram

GLOSSARY

After-ripening: Period during which changes take place in seeds to prepare them for germination. In nature, such changes are brought about through seasonal variations.

Asexual propagation: Propagation of plants by means other than fertilization. Cuttings, layers, and grafts all are asexual methods of propagation, involving the increase of plants through ordinary cell division and differentiation.

Auxins: Organic substances that organisms produce in minute amounts. In plants their action regulates plant growth, influences flower and fruit production, root initiation, etc.

Basal: At the base of; on cuttings the basal end is that which was closest to the roots of the stock plant.

Bench: A raised structure used in a greenhouse to hold potted or flatted plants, propagating or soil media in which plants are grown. Usually planned so all parts can be reached from aisles. Benches vary widely in design.

Bloom: A powdery surface coating found on some fruits and leaves.

Bud: An undeveloped shoot or flower, usually enclosed by scales or scale-like leaves.

Budding: A grafting procedure in which the scion consists of one bud.

Budstick: A shoot cut from a plant for the purpose of using its buds for bud-grafting.

Callus: A mass of undifferentiated cells that develop around wounded plant tissues. It arises mostly from cambial tissue and is frequently associated with the rooting of cuttings and the healing of graft unions.

Cambium: A layer of meristematic tissue found between bark and wood of woody plants, the cells of which are capable of dividing to produce new tissue. Responsible for the successful regenerative activity of woody plants (i.e. production of roots on cuttings, formation of graft unions, etc.)

Capillary action: The movement of a liquid into fine tubes or spaces because of its surface tension.

Carpel: The female or ovule-producing organ of a flower, composed of ovary, style, and stigma.

Clone (Clon): Defines a category of genetically uniform plants, all propagated from a single individual by vegetative means.

Cold frame: A shallow unheated structure placed on or in the ground out-of-doors and covered with glass or plastic. Used for carrying small hardy plants over winter, propagating seedlings and cuttings in spring and summer, and holding plants between greenhouse and nursery. Mitigates extreme temperature fluctuations.

Cold stratification: Treatment of seeds with a period of moist cold conditions to break internal dormancies.

Compatibility: The degree of affinity between stock and scion of a graft union, as expressed by subsequent growth, vigor and longevity of the grafted plant. Plant parts which form a strong, healthy union when grafted together are said to be "compatible."

Cone: Reproductive structure (often loosely termed "fruit") of the gymnosperms. There are two types of cones: pollen-bearing (male) and seed-bearing (female).

Conifer: Any of the cone-bearing trees or shrubs among the gymnosperms. Includes those plants such as yew and juniper which bear modified cone-like structures.

Controlled storage: Any of various methods used to maintain high viability in seeds until they are needed.

Cotyledons: The primary leaf or leaves of an embryo. They may function as leaves after germination or may contain food reserves for initial seedling growth.

Cultivar: A term derived from "cultivated variety." A taxon known only in cultivation; named, selected and propagated for its desirable characteristics.

Cutling: A plant of any size or age that has been grown from a cutting.

Cutting: A severed portion of a plant, usually capable of regenerating shoots and/or roots which allow it to grow into an independent individual.

Cutting, hardwood: A stem cutting made from the mature woody shoot of a dormant plant.

Cutting, softwood: A stem cutting made from an actively growing shoot which has not yet become woody.

Dioecious: The condition in which cones of each sex are borne on separate plants.

Dormancy: Period during which plants become inactive so they can survive periods of adversity. Quiescent condition in seeds which remains until specific requirements for germination have been fulfilled.

Double dormancy: Dormancy in a seed having two barriers to germination, usually seed coat impermeability plus internal conditions. Sometimes called "two-year" seeds.

Embryo: The rudimentary plant within a seed.

Embryo dormancy: Dormancy due to conditions of the embryo. The embryo requires some environmental stimulus before it will resume growth.

Established understock: A rootstock which has been potted at least one growing season in advance of its use.

External dormancy: Dormancy caused by seed coats which retard the entry of water or oxygen. Sometimes called seed coat dormancy.

Fanning: The process of removing extraneous matter from seeds by using a current of air. Also called "winnowing."

Fascicle: In conifers, a cluster of needles.

Fertilization: Union of the sperm or male sex cell from the pollen grain with the egg nucleus or female sex cell inside the ovule, resulting in the development of an embryo inside a seed.

"Fire" pines: Species of pine whose seeds are not normally released until the cones have been exposed to the heat of a fire.

Fixed juvenile: A plant which fails to pass from the juvenile stage characteristic of seedlings to the adult stage found in mature plants.

Flat: A shallow wood, plastic, or metal tray supplied with drainage holes and used for germinating seeds, rooting cuttings or raising plants. Flats are available in a wide variety of sizes.

Flotation: A technique based on differences in specific gravity for separating seeds from pulp debris. Seeds usually sink when placed in a column of water, while pulp floats and can be poured or floated away.

Frame: See "Cold frame" and "Hot bed."

Fruit: The developed ovary of a flowering plant, including seeds and accessory structures.

Gene: The basic unit of inheritance which determines the characteristics of a plant.

Gene mutation: A sudden specific change in a gene which causes a concommitant change in the characteristics of the plant, or plant part, growing from the cell in which the mutation occurred.

Genetic variation: Inherited variation in the characteristics of a plant.

Genus: A category of classification lower than a family and higher than a species.

Geographical races: Variations of a taxonomic species, based upon subtle deviations from the typical form. Related to specific peculiarities of a climatic region.

Germination: The resumption of growth by an embryo and its development into a seedling. Prior to germination the conditions for breaking dormancy must have been satisfied and environmental conditions must be favorable.

Germinative capacity: The percentage of seeds in a given lot that are potentially capable of germination.

Girdling roots: Roots which establish a circling pattern during confinement in containers, sometimes leading to "strangulation" and death of the plant.

Grafting: The art of joining parts of plants so that they will unite and grow as single individuals.

Graft union: The point at which stock and scion are joined in a grafted plant.

Hardiness: Ability of a plant to survive the climate of a given geographical location.

Hardening-off: Any of various methods used to condition plants so that they will not suffer when transferred from one environment to another.

Hormone: A substance naturally produced in one part of a plant and transported to another part where, in extremely minute quantities, it is capable of producing marked growth effects.

Hot bed: A structure essentially identical to a cold frame, but supplied with supplemental bottom heat by electrical cables, hot water steam pipes, or decomposing manure.

Hybrid: The offspring of a cross between two taxa.

Incompatibility: When applied to a graft union, a lack of affinity between stock and scion, usually expressed by failure, poor or abnormal growth, lack of vigor, or overgrowth, of the stock or scion. Grafted plants which fail to form a satisfactory graft union are said to be "incompatible."

Indolacetic acid: A chemical compound commonly used as a synthetic auxin. When applied to cuttings, it promotes the production of roots. Frequently abbreviated "IAA."

Indolbutyric acid: A chemical compound commonly used as a synthetic auxin. When applied to cuttings, it promotes the production of roots. Frequently abbreviated "IBA."

Internal dormancy: Dormancy due to conditions within the seed, either in the stored food or the embryo.

Juvenility: Physiological condition usually associated with the seedling stage of plants. It may or may not be visibly apparent, and it persists for varying lengths of time.

Lateral: In referring to buds or shoots, one found on the side, rather than the tip, of the branch.

Layer: A plant part which produces its own roots while still attached to the parent plant.

Layering: The development of roots on a stem while it is still attached to the parent plant. The stem is detached after it has formed enough roots to sustain itself.

Loam: Soil having moderate amounts of clay, sand, and organic matter.

Longevity: Length of life. In seeds, the period of time they remain viable under specified environmental conditions.

Maceration: The process of crushing fleshy fruits or cones so that the pulp and seeds can be readily separated by flotation techniques.

Medium: The substance in which plants are grown, cuttings are rooted, seeds are stratified, etc. Plural is "media."

Microsporophyll: In seed plants, a modified leaf-like organ bearing pollen sacs.

Milled sphagnum: Sphagnum moss ground to a particle size suitable for use in sowing seeds.

Mist system: Device consisting of nozzles and control mechanisms designed to keep cuttings from desiccating as they root by maintaining a film of water on the leaves. An *intermittent mist system* operates at intervals frequent enough for the cuttings to maintain their turgor.

Moisture content: In reference to seeds, the amount of moisture contained, expressed as a percentage. It can be significant in the retention of seed viability during storage.

Monoecious: The condition in which cones of each sex are borne on the same plants.

Monotypic genus: A genus comprised of one species.

Naphthalene-acetic acid: A chemical compound commonly used as a synthetic auxin. When applied to cuttings, it promotes the production of roots. Frequently abbreviated "NAA."

Non-viable seed: Seed which lacks the capacity to germinate.

Ovule: Immature seed borne on the scales of female cones in gymnosperms. The ovule contains the female sex cell before fertilization. At maturity, it becomes the seed.

Pathogenic organisms: Organisms capable of producing disease.

Peatmoss: An organic substance formed by partial decomposition of sphagnum moss in water and used by horticulturists to modify soil mixtures and aerate media.

Photoperiod: The relative length of light and darkness in a day. It has marked influence on the behavior of plants.

Pollen: Bodies containing the male cells which fertilize the egg's nucleus to produce an embryo. Borne in sacs on the scales of male cones in gymnosperms.

Polyethylene plastic structure: A structure designed to prevent plant cuttings from desiccating while they are developing roots. It consists of polyethylene plastic film supported by some sort of framework.

Pretreatment: As applied to seeds, any measure used to overcome dormancy in seed before it is sown. Seed coat modification and stratification are methods of pretreating seeds.

Propagant: The plant resulting from any propagating technique.

Propagation: The multiplication of plants by seeds, cuttings, layers, grafts, etc. (See "Asexual Propagation" and "Sexual Propagation".)

Propagule: A plant part capable of growing into a new individual.

Relative humidity: The amount of water vapor in the atmosphere expressed as a percentage of the total amount which the air is capable of holding at a given temperature.

Respiration: The metabolic processes by which a plant oxidizes its food material. Oxygen and carbohydrates are assimilated into the system and oxidation products are given off.

Root-inducing substances: Materials used to stimulate root initiation on cuttings of plants. Those most commonly used are IBA (indolbutyric acid) and NAA (Naphthaleneacetic acid), both artificial compounds which act like natural plant auxins.

Root initials: Groups of cells which arise in cuttings and are the first step in the development of roots. Those already present in shoots before they are removed from the parent plant as cuttings are called "preformed root initials."

Rootstock: The portion of a graft combination which becomes the root system of the grafted individual. Sometimes called "understock."

Rubber budding strips: Rubber strips specifically designed for tying bud grafts and for binding newly made graft unions. They are manufactured in a variety of sizes.

Secondary dormancy: Return to the dormant condition after the initial dormancy has been overcome. Usually caused by unfavorable environmental conditions.

Scale: In female conifer cones, the bract-like appendages which are attached to the central woody axis and which bear seeds on their upper surfaces.

Scarification: Alteration of a seed coat through the use of an abrasive technique so that it becomes permeable to water or air. *Mechanical scarification* involves breaking, scratching, or otherwise mechanically altering the seed coat. *Acid scarification* involves eroding it with acid.

Scion (Cion): The portion of a graft combination which develops into the stem and leaves of the new individual.

Scorching: Parching or shriveling of leaves. Occurs when plants are not properly hardened-off before being moved from one environment to another.

Screening: A process for separating extraneous matter from seeds. The mixed material is passed through a screen with mesh coarse enough to retain either chaff or seeds, but not both.

Seed: A ripened ovule consisting of an embryo and stored food enclosed by a seed coat.

Seed dormancy: Inhibition of seed germination due to restrictive internal, external, or environmental conditions such as those related to temperature and moisture.

Seed coat dormancy: Dormancy due to a seed coat which retards the entry of water or oxygen. Sometimes called external dormancy.

Seedling: Any plant raised from a seed; often used to indicate such a plant while it is young in age.

Seed lot: A batch of seeds, usually from a single, specific source, which may be of any quantity.

Seed pan: A shallow pot of clay or plastic, available in a wide range of sizes. About two-thirds the depth of a standard pot.

Serotinous: Flowering or fruiting late in the season. Applied to cones of gymnosperms that remain closed on a tree for prolonged periods after they have matured.

Sexual propagation: Propagation of plants by seeds, formed upon the union of sperm and egg cells.

Shield budding: A grafting procedure in which the detached scion bud and wood resembles a shield. It is inserted into a "T"-shaped incision in an understock.

Shoot: A flush of growth arising from a single bud.

Side graft: A grafting technique in which the scion is inserted in the side of the understock. The topgrowth remains, sustaining the plant until the scion has made growth.

Simple layer: A layering technique in which a plant is propagated by bending a girdled branch into a trench, fastening it down, and covering it with soil to induce it to produce its own roots.

Species: A category of classification lower than a genus or subgenus and above a subspecies or variety. The basic category of classification. In nature, individuals of one species normally interbreed.

Sphagnum moss: Any mosses of the genus *Sphagnum*, found in wet, boggy areas and valued for their water-retaining and antibiotic qualities.

Standard: A plant grown with a single, erect, tree like stem. Often achieved by budding or grafting on a tall stem.

Stratification: Any process used to encourage germination of dormant seeds which require pretreatment by time, temperature, and moisture.

Stratification medium: Any material used to keep seeds moist during stratification; often organic peat, sand, or sawdust.

Synergy: The effect of two or more substances which together have a greater effect than the sum of their individual effects.

Taxon: A term referring to any taxonomic unit, such as species, variety, or cultivar. Plural is "taxa."

Terminal: In the propagation of plants by cuttings, the terminal end is the distal part of a branch.

Transpiration: The evaporative loss of water vapor from leaves.

Turgor: The firmness of plant tissues as influenced by the fluid content of cells.

Understock: See "rootstock."

Variety: A category of classification within a species based on hereditary differences from the species. A wild population of plants differing from other varieties in one or more characteristics, but not sufficiently different to be a species.

Vector: An organism which acts as a carrier, i.e. of seeds, diseases, etc.

Vegetative dormancy: Resting condition of plants or vegetative parts of plants, such as buds or roots, due to low temperatures, drought, or the presence of inhibiting hormones.

Vegetative propagation: See "Asexual propagation."

Veneer graft: A type of side graft.

Vermiculite: A product manufactured by expanding mica under high temperatures. It is light in weight and retains water and nutrients but does not hold its structure well.

Viability: Capacity to renew growth; in seeds, the ability of a certain seed lot to germinate and grow under favorable circumstances, expressed as a percentage.

Warm stratification: Warm pretreatment of seeds under moist conditions at about room temperature to bring about external or internal change. Such treatment precedes cold stratification.

Whip-and-tongue graft: A grafting technique in which the topgrowth of the understock is removed prior to grafting. Tongues are cut into the sides of rootstock and scion and the two are fitted together to form the graft union.

Wing: A membranous appendage to a seed which facilitates wind dispersal.

Winnowing: See "Fanning."

Woody: The parts of trees and shrubs which persist for more than one year. Often qualified as to degree of maturity, i.e. softwood and hardwood cuttings, etc.

Wounding: A term used to define the slitting, cutting, or otherwise damaging of the basal ends of stem cuttings. It can remove a physical barrier to root emergence, expose more surface to the action of root-inducing materials, and lead to more extensive root systems.

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Cover: Crocus, fragile harbinger of spring. Photo: P. Chvany.

The Early Rock Garden

by George H. Pride

Here in the north it is hard to imagine anything that can give more pleasure to a gardener than a rock garden featuring hardy plants that bloom early in the spring. During the month of May in this area almost any rock garden can be spectacular without much effort; every bit of bloom that appears earlier, therefore, is prized in a special way. The plants capable of making a fine showing this early are really more numerous than most people realize, and with some judicious planning, the display can begin in early March. In fact, in my rock garden there are two plants, *Narcissus bulbocodium* 'Nylon', and *Merendera sobolifera*, that become so enthusiastic about being "first" in the spring that they frequently end up being "last" each fall.

Before going into discussions of plants it is well to set the stage. The main source of information for this article is a rock garden at the Case Estates in Weston, Massachusetts, that has been under my care for nearly ten years. Although it is a relatively small garden, it contains over 1,000 species and cultivars; the majority of them coming into bloom in May or soon after. This garden is in Zone 4.5 according to the Arboretum map, but I have found micro-habitats in it which allow plants to do well that normally would be much happier in warmer areas. There will be no effort to include every possible rock garden plant that might grow here; only those that I have had experience with in this garden will be considered. Most of the plants included are available from nurseries listed at the end of this article. A few however, like the merendera, will be difficult to obtain without much search, or through contacts in foreign countries. They will be worth trying to get, nevertheless.

To put some system into this large array of plants, it seems to make the most sense to discuss them alphabetically by genus. Then, at the end of the article there will be a listing by time of bloom.

Adonis, first in the list, is also among the first of my favorites in the early rock garden. I have enjoyed especially the cultivar 'Fukujukai' of the species *A. amurensis*, which glows with a golden light and blooms from the middle of March to the end of April some years, depending upon the weather. This past spring, it was at its peak of beauty when the temperature reached 67° F on March 20th. This special cultivar is available from several sources.

A plant that waits until May to flower, but has a tidy appearance throughout most of the year, is *Alyssoides utriculata*. It is sometimes

Adonis amurensis '*Fukujukai*'. *Photo: G. Pride.*

listed as a *Vesicaria*. The flowers are a greenish-gold shade. The seed pods that follow are inflated, making the plant one of the showiest in late June and July.

It would be hard to imagine a rock garden without anemones. *Anemone blanda* from Europe, flowering here in mid-April, is available in shades of pink, deep blue and white; a cultivar, 'Radar', is a brilliant purplish-red with a white center. The finest for me has been 'White Splendor', which persists and flowers well each year. The European Wood Anemone, *A. nemerosa*, is available in many colors and forms, all good. Perhaps the easiest and showiest of all is *A. ranunculoides*, the Yellow European Anemone, which asks only for a bit of extra moisture in the soil and full sun to establish itself and spread rapidly. It is especially fine here in April. The many colors and forms of what was once known as *Pulsatilla vulgaris* and is now usually called *Anemone pulsatilla*, with the common name of Pasque Flower, serve a double purpose in the garden. They flower in the middle of April, then produce large fluffy seed heads that are as attractive as the flowers. Ordinary soil suits them well. I have found 'Camla' to be an excellent cultivar.

Right: Anemone pulsatilla '*Camla*'. *Photo: G. Pride.*

Anemone blanda. *Photo: G. Pride.*

The maddening problem of scientific name changes is especially common in rock gardening because so many different families, genera and species are involved. Once one has learned a scientific name for a plant it becomes unpleasant to have to learn a new name for an old friend. I grew up enjoying *Anemonella thalictroides*, the Rue Anemone, which some now consider a *Thalictrum* — giving us the odd name of *Thalictrum thalictroides*, which means the "thalictrum that looks like a thalictrum." In middle to late April this species and some of its very unusual or even strange cultivars make tiny, fragile, fascinating woodland-rock garden subjects.

Our wild Marsh Marigold is represented in the garden by the dwarf double flowered form, *Caltha palustris* 'Nana Plena', a very welcome addition in late April in a somewhat moist spot.

Chionodoxa, the Glory of the Snow, is commonly grown. *C. luciliae* seeds in easily and produces sheets of exquisite blue in early to middle April. Another species, *C. gigantea*, with larger but paler blue flowers is almost as easily adapted. The *Chionodoxa* cultivar called 'Pink Giant' is one of the most exciting of all early rock garden plants. I know of no other plant with flowers of this shade of pink blooming at this time in the rock garden. It is worth making every effort to obtain the bulbs. It will slowly seed in and should be isolated from the others to keep its "purity."

Chionodoxa *'Pink Giant'. Photo: G. Pride.*

Reginald Farrer, one of the tartest-tongued gardeners to ever evaluate plants, referred to *Claytonia*, the Spring Beauty, as "pretty little weeds" becoming in a few years "an irrepressible pestilence." They spread a candy-pink and white mist over the ground when they flower for a relatively long time during April, but the plants soon disappear completely until flowering time next year.

Several corydalis make excellent rock garden subjects. *Corydalis sempervirens*, our native Pale Corydalis, is definitely a weed in my rock garden, but a lovely one — especially in flower against greyish rocks. *C. bulbosa* and *C. densiflora* are far from weeds. The latter blooms near the end of March, and the former during the first week of April. They are both shy, non-spreading, attractive and eagerly anticipated each spring. They may be difficult to buy, but are worth hunting for.

I am sure that the average rock garden connoisseur would be shocked to know that the only draba I have succeeded with year after year is *Draba sibirica*. I look forward annually to its lacy masses of tiny golden flowers. It is as dependable as the seasons and is at its best in my garden during the first week of April.

Anemone ranunculoides. *Photo: G. Pride.*

Corydalis bulbosa. *Photo: P. Chvany.*

Certainly crocus are the mainstay of the early rock garden. They are easy, colorful, problem-free and most welcome in the early spring. I have avoided the large-flowered hybrids and concentrated on the species *Crocus tomasinianus*, and the many cultivars of *C. chrysanthus*. The first is easy, persistent and lovely, though the flowers are somewhat fleeting. All cultivars of *C. chrysanthus* are early and worth growing. Some will start to flower in late February in favorable years and others will still be showy in early April. I have enjoyed immensely the cultivars 'Lady Killer', a rich purple edged in white;

'Gypsy Girl', golden yellow feathered purplish; 'Goldilocks', a rich yellow; 'Princess Beatrix', a magnificent shade of blue; 'Snow Bunting', the nicest white; and a brownish-gold called 'Zwanenburg Bronze'.

The composite family is conspicuously rare in the early rock garden. The cultivar 'Finesse' of *Doronicum caucasicum* (or should it be called *D. cordatum*?) is usually blooming by the middle of April with attractive golden daisy-like flowers on dwarf plants.

Dicentras are so well known, so generally easy, and so effective that all one needs to say is grow as many as you can. Both *Dicentra cucullaria*, the Dutchman's Breeches, and *D. canadensis*, Squirrel Corn, prefer the woodsy side of the rock garden. Both are at their best in the early part of April; both seed in easily if they like their surroundings.

It is hard to imagine the early spring garden without Winter Aconite, and the species *Eranthis hyemalis* seems to be as good as any. Even though it is an extremely hardy plant, a bit of patience may be needed to establish it, but from then on it is with you forever.

Call them what you will, Adder's Tongues, Trout Lilies, Dog-tooth Violets, or Fawn Lilies, the erythroniums all are very attractive, hardy, and mostly easy doers. They are at their best in middle April. I strongly recommend the violet-purple flowered *Erythronium japonicum*, the lavender-purple *E. hendersonii*, and the various cultivars of *E. dens-canis*, which come in shades of rose to purple-violet as well as white. Two of these that are especially striking and usually available are 'Frans Hals' and 'Snowflake'. Some erythroniums have delightfully attractive leaves mottled with reddish-brown.

Erythronium hendersonii. *Photo: G. Pride.*

A strange prostrate plant from the Mediterranean, *Euphorbia myrsinites*, is one of the few members of the euphorbia family to be of value in the rock garden. Despite its place of origin, it seems to be very hardy, flowering rather inconspicuously in middle April. It gives a different look to its special place in the garden.

Certainly the easiest of all the fritillaries is the Checkered-Lily, *Fritillaria meleagris*. Several cultivars are available, all excellent and easy to grow and all flowering in May with one exception: the earliest in my garden is 'Saturn', which flowers consistently in late April. All the cultivars are so hardy that bulbs heaved during the winter will go on flowering after being poked back in the ground.

Nothing says "Spring is coming" more clearly than the first snowdrops. Depending upon how sheltered the spot is, one may expect flowering any time from late January through February and into late March. *Galanthus nivalis*, the common snowdrop, is the only one I grow in the rock garden. It is usually at its best in late March.

I have never had a Christmas Rose flower for me at Christmas time. The species *Helleborus niger* and its subspecies *macranthus* are apt to be flowering from late March to middle April. Most gardeners know that one way to get the earliest and most perfect flowers is to place a low wooden box around each plant, leaving the top open and mulching heavily with deciduous leaves. Parting the leaves at the proper time will reveal flowers in excellent condition undaunted by the severest of weather.

Hepatica, both *H. acutiloba* and *H. americana* (*H. triloba*), and the Eurasian species, *H. nobilis*, flower from the last week of March to mid-April. I especially like the cultivar 'Ballard's Variety' with lovely soft lavender-blue flowers nearly an inch in diameter.

To those who grow only the tall bearded iris, the species and their variants in the early rock garden can be a revelation. Certainly *Iris reticulata* with its many forms and colors is the most interesting. They are excellent for rock gardens, easy to grow and flower, and increase reasonably well. They also stand up to very bad weather conditions which are apt to occur when they are in flower. The earliest in my garden is 'Springtime', which blooms in late March, followed by 'J.S. Dijt', 'Violet Beauty' and 'Harmony'. Later in April, 'Joyce' and 'Jeannine' are fine, and the latest has been 'Wentworth' — flowering in late April or early May. Thus, by careful planning, nearly a month and a half of these delightful iris may be enjoyed.

Iris danfordiae, with deep greenish-gold flowers, blooms early in April. It is spectacular, but many growers complain that after the first year of flowering the corms tend to split up into many small cormlets that take years to flower again. Two suggestions I have not tried that seem to work with others are to plant the corms much deeper than normal, and to feed the plants with weak solutions of manure water while they are in bloom, continuing until the plant dies down naturally. In middle March, *I. histrioides* and its cultivar

'Major' draw all attention to themselves. The flowers are an intense violet-blue and are large for the size of the plant. In 1976 a very heavy snowstorm occurred right after their flowers had opened with no noticeable harm.

A remarkable hybrid between *Iris histriodes* 'Major' and *I. danfordiae* is 'Katherine Hodgkins', which shows hybrid vigor and increases well. Its large flowers of a strange but attractive turquoise-chartreuse are unique. The flowering time is almost exactly between the two extremes of its parents. Expensive, hard to find now, and coveted by all who see it, it is bound to be grown widely when there is sufficient stock available.

Our native *Jeffersonia diphylla* and the Asiatic *J. dubia* have flowers that can best be described as fugacious. Were it not for the very attractive leaves and the equally unusual seed pods, the plants would be recommended with reservation. Known as Twinleaf, they flower in early April and are edge-of-the-woods rock garden plants.

Merendera sobolifera, a member of the lily family and a bulb that is rarely grown, has bloomed in late November and again in February through what appeared to be frozen ground. Admittedly it is not a showy plant, but its small, very ragged pale bluish flowers and tiny narrow leaves are very welcome in the desolation of late winter. It will be hard to find in any catalog. It is not mentioned in the new "Hortus III."

In a moist corner, the Virginia Bluebell, *Mertensia virginiana*, is a striking plant in mid-April. Dying down and disappearing soon after flowering, it can be grown in association with other plants that would normally follow it.

Many Grape Hyacinths are available for rock garden work and are easily grown and remarkably persistent. I especially enjoy the two that are earliest for me: *Muscari armeniacum*, the Early Giant Grape Hyacinth from Asia Minor, and the relatively new bright blue *M. tubergenianum* from N. W. Iran. These are followed by others that flower mostly in May.

If I were confined to growing only one kind of bulbous plant in the early rock garden, it would have to be *Narcissus*. Earlier I mentioned 'Nylon', a cultivar of *N. bulbocodium*, the Hoop-Petticoat Daffodil. This obliging plant has flowered beautifully for me in November and December as well as in April, which I suspect would be its normal flowering time here. I should emphasize that all the variants of this species are well worth growing. Anyone who has been fortunate enough to visit Wisley in England when the alpine meadow is in bloom will have seen an unforgettable sight of masses of these plants. The varieties *citrinus*, *conspicuus*, *obesus* and *romieuxii*, flowering mostly in mid-April, all are fine. Under ideal conditions these very hardy plants will be free-seeding and will build up colonies. Other very desirable species that provide great charm with only a few plants are *N. asturiensis* (*N. minimus*), which has a tiny deep yel-

low trumpet on a plant only 4 inches high; *N. cyclamineus*, blooming in early April; *N. rupicola*, a dwarf yellow daffodil flowering in middle April; and Angel's Tears, *N. triandus* var. *albus*, with an exquisite pure white nodding flower appearing at the same time. A species deserving special mention is *N. watieri* from the Atlas Mountains of Morocco. This tiny white jonquil blooms in April and seems to be completely hardy, but likes to dry out well in the summer. More gardeners should know it.

Named narcissus cultivars that are excellent for the rock garden in order of their flowering for me are 'Little Beauty' in early April; 'Little Gem'; 'Tete-a-Tete'; 'February Silver', despite its name, flowering in middle April; 'Trevithian', one of the finest of all jonquils; and 'Jumblie' in late April.

Pulmonarias, the lungworts, seem to be suffering from nomenclatural woes. "Hortus III" lists only four species. Other authorities list more and different ones. I have grown and enjoyed two in the moister part of the rock garden. *Pulmonaria affinis* flowers in early April with white spotted leaves and flowers opening pink and changing to purplish-blue. Blooming a bit later, *P. angustifolia* also bears spotted leaves and flowers opening pink but changing to a bright blue.

Looking much like a scilla and closely related is *Puschkinia libanotica*, which also is known as *P. scilloides*. It is very hardy and very early flowering, usually in full bloom by the first week of April. The flowers are watery blue with a dark stripe through the center of each petal and sepal.

The edge of the wild flower garden that blends into the rock garden is where I have grown the few primroses that I am able to enjoy. The true primrose fancier will be unhappy about the few that I have, but I have found that only a limited number persist under my conditions and perform well each year. *Primula* × *Juliana* 'Dorothy' is reliable for mid-April. The bright yellow 'Butterball' and rich red-purple 'Wanda' are both sure to be there each spring.

A pretty weed from Europe, *Ranunculus ficaria*, the Lesser Celandine, may be controlled by pulling up and discarding a good amount of it each year. Its blooming time is brief, around the middle of April, and its small golden yellow flowers soon disappear followed by the rest of the plant. One often forgets that it is there until it reappears the next spring.

I find the native bloodwort, *Sanguinaria canadensis*, seeds in easily all about the rock garden. Its brief but attractive flowers are welcome; but its amazing relative, the double-flowered form, is one of the few multi-petaled plants that can be accepted without a feeling of abnormality. This double-flowered cultivar is now quite widely grown and probably is correctly called 'Multiplex'. It is seedless and will last in flower a long time. In middle April the multi-petaled bloodroot is a brilliant sight in any garden, completely eclipsing its normal wild relative.

Puschkinia libanotica. *Photo: P. Chvany.*

Primula × Juliana '*Butterball*'. *Photo: G. Pride.*

All scillas appeal to me, but I have two favorites: the special form of *Scilla siberica* called 'Spring Beauty', which is larger in all parts than the species and to me a truer blue, and *S. tubergeniana* from Northern Iran, with pale blue flowers accented by a darker stripe in each segment. It will start to bloom in mid-March and last well into April. I understand a British authority claims it should be called *S. mischtschenkoana*. Take your pick.

In the wild garden/rock garden area, trilliums thrive. My favorite is *Trillium nivale*, the Snow or Dwarf White Trillium. In 1976 it flowered on March 14th and stayed in excellent condition for three weeks under very rough weather situations. At best it may reach 6 inches. If it likes its habitat, seedlings will appear and in time a colony will form. *T. grandiflorum* and *T. sessile* and its forms are hard to do without, although I think of them as wild garden subjects rather than as rock garden candidates.

Several species of tulip supply the brass in the spring orchestration. Grown in a sunny spot that bakes in summer, they persist for many years and are amazingly free from disease and troubles. Very early

and very lovely is *Tulipa pulchella* 'Violacea' which, as its name implies, has very attractive violet flowers and is at its best in the first week of April. It is soon followed by *T. greigii*, the many forms of *T. kaufmanniana,* and *T. linifolia.* This last is a showy dwarf of brilliant scarlet with a black center that opens out flat in bright light. Its brilliant shimmering red almost hurts one's eyes in the sun. Then comes 'Fusilier', a cultivar of *T. praestans*, followed by *T. tarda* and *T. turkestanica* in mid- to late April.

Finally I have many pansy and viola "volunteers" that pop up here and there in the rock garden. I will find them in bloom at almost any time of the year, but they are especially welcome in early March or April. This year a lovely blue, large-flowered one seeded into the crevices in the rocks above the gentian bed and was the last plant to flower, still greeting visitors in late December!

Sanguinaria canadensis *'Multiplex'. Photo: G. Pride.*

Anemone blanda *'White Splendor'. Photo: G. Pride.*

Flowering Times (very general)

February
Crocus (into April)
Galanthus nivalis (into March)
Merendera sobolifera

March (early to middle)
Adonis amurensis 'Fukujukai'
Eranthis hyemalis
Iris histrioides
Scilla sibirica, S. tubergeniana (into April)
Trillium nivale

March (late)
Corydalis
Helleborus niger
Hepatica
Iris reticulata (to late April)

April (early)
Chionodoxa
Dicentra
Draba siberica
Iris danfordiae
Jeffersonia
Narcissus cyclamineus
N. 'Little Beauty'
Pulmonaria affinis
Puschkinia libanotica
Tulipa pulchella 'Violacea'

April (middle)
Anemone
Doronicum caucasicum 'Finesse'
Erythronium
Euphorbia myrsinites
Mertensia virginiana
Muscari (into May)
Primula
Pulmonaria angustifolia
Narcissus bulbocodium, N. rupicola, N. triandus var. *albus, N. watieri, N.* 'February Silver', *N.* 'Little Gem', *N.* 'Tete-a-Tete'
Ranunculus ficaria
Sanguinaria canadensis
Thalictrum thalictroides
Tulipa greigii, T. kaufmanniana, T. linifolia, T. praestans 'Fusilier'

April (late)
Caltha palustris 'Nana Plena'
Claytonia
Fritillaria meleagris 'Saturn'
Narcissus 'Jumblie', *N.* 'Trevithian'
Tulipa tarda, T. turkestanica

Shrubs and Shrublets

No treatment of the early rock garden is complete without a reference to these woody relatives which may or may not be in flower before May, but even out of bloom add immensely to the attractiveness and patterning of the garden.

A great pet of mine is *Andromeda polifolia* 'Nana' which looks well year round, especially when its charming flower bells appear in May.

Bearberry, Mealberry, Hog Cranberry, Sandberry, Mountain Box, Bear's Grape or Kinnikinick all are common names for *Arctostaphylos uva-ursi.* Providing no lime is in the soil, this native prostrate creeper can add greatly to any rock garden. Its pinkish-white flowers may start to open as early as late April.

The Dwarf Arctic Birch, *Betula nana*, is another favorite, rarely reaching 2 feet in height. It loses its dainty, tiny toothed leaves in the fall and regrows them rather late in the spring. I have never seen it in flower, but it is a fine addition to the rock garden even when leafless in winter.

Bruckenthalia spiculifolia, the Spike Heath, is an evergreen heath-like shrub and a fine addition to any rock garden. It rarely reaches a foot in height and it waits until June to produce its small pinkish flower clusters.

Heathers belong in every rock garden for the year-round effect and the texture they offer. For the most part they flower in late summer. The one I would like to single out from all others is *Calluna vulgaris* 'Foxii', which forms a slow growing, compact, dense green cushion. It produces a few wispy small pink flowers in late summer, but looks better without them the rest of the year.

Few gardeners I know have grown a remarkable plant from New Zealand called *Carmichaelia enysii.* I find no common name for this member of the legume family. It has congested, flat, light green branches and small pealike violet colored flowers that are fragrant and borne in great quantity in June. If it grows much above a few inches in height, rabbits seem to find it and chop it back. Try it in the warmest, sunniest spot in the rock garden. It is a treasure to be enjoyed at close range.

It is difficult to know what to say about the cassiopes. I have tried most of them and found them hard to please. They seem unhappy with my growing conditions and the little dwarf, prostrate whipcord-like branches have only rarely had a few tiny flower bells; a far cry from the magnificent things they can be when growing wild in their native areas. Try them if you want to struggle with something well worth the time and effort when you are successful.

Two daphnes, one common and one relatively rare in gardens, are worth their place in the rock garden. *Daphne cneorum* is well known

to gardeners and attractive most of the year though the flowers usually appear in May or later. A much earlier flowered daphne is *D. blagayana*, which bloomed last year on April 8 and was followed right after by a freeze of 12° F which badly browned the attractive pinkish-white flowers. Evergreen, straggling, and rarely reaching more than a foot in height, it has creamy pink flowers that are very fragrant and most welcome in the early spring.

The ericas or heaths are valuable shrubs for the rock garden the year-round but are appreciated especially for their early flowers in March. *Erica carnea* 'Springwood White' and 'Fox Hollow' are fine; somewhat later in April, 'Arthur Johnson' adds its pink bells to the garden scene.

Lavender is marginally hardy in the rock garden area. I have found the most satisfactory and permanent variety to be one that goes by the name of *Lavendula officinalis* 'Nana Compacta'. It is a beautiful, soft greyish-green all year-round; the small flower heads appear in mid-July.

To me, the most pleasing of all mints is *Mentha requienii*. It is not woody and plants will not live through the winters here, but once established, it produces tiny lavender flowers that in turn produce abundant seeds that do survive the cold to start new plants each year. It has three common names: "Menthella," "Corsican Mint," and the "Creme-de-Menthe Plant." The last name is very appropriate for no one ever forgets the wonderfully intense mint fragrance that this plant gives off when bruised. It may be enjoyed as a house plant and returned to the rock garden in the spring.

The *Pieris* that seems to be just right for rock gardens is 'Millstream'. A fine addition throughout the year, it is generous with its sprays of white bells in the first week of April. It is a highly recommended origination from the garden of Lincoln Foster in Falls Village, Connecticut.

The woody polygalas should be grown more than they are. *Polygala chamaebuxus* and its variety *grandiflora* (*P. chamaebuxus* var. *purpurea*) are fine, low, bushy plants and always enjoyable even though the small pealike flowers do not appear until mid-May.

Many potentillas are of year-round value in the rock garden. My favorite is *Potentilla rupestris* var. *pygmea*, a delightful prostrate shrublet that flowers in early May.

There is a wide selection of rhododendrons that can be great assets to the rock garden. The outstanding one in this garden has been *Rhododendron degronianum*, which received the Award of Excellence of the American Rhododendron Society and is sold as 'A. E. Form'. It is very dwarf, about 1 foot high, and yet has large clusters of deep pink flowers in late April or early May. Two others also have been very exciting. The very dwarf form of *R. keiski* placed in the most sheltered niche in the whole garden is delightful even out of flower. The soft yellow flower bells may not appear until the first

part of May. A remarkable plant from Formosa is *R. nakaharai*, a little creeping evergreen azalea with brick-red flowers in June. It took several years to form a charming "bonsai shape" and this last year rewarded me with a few flowers. It is an attractive plant throughout the rest of the year even when not in bloom. It is supposed to stand temperatures as low as −10° F.

Other rhododendrons I can recommend either because of their low growth, attractiveness, or early bloom are *Rhododendron impeditum* and the hybrid clones 'Purple Gem' and 'Ramapo'.

I have grown only one willow in this garden. It is in the trade as *Salix* × *moorei* and apparently is a natural hybrid between *S. herbacea* and *S. phylicifolia*. Hillier's catalog says it was found in Scotland. In "Shrubs For the Rock Garden and Alpine House," Heath claims it was found in Ireland. Wherever it came from it makes a low wide-spreading mound of slender green stems with small glossy green leaves. When my plant grew big enough to flower, it produced tiny reddish-yellow pistillate catkins early in the spring, well before the leaves came out. It is relatively slow growing; but there is a possibility of using it for a ground cover if it can be propagated readily. It has never reached a height of 1 foot in this garden.

I consider most thymes prostrate shrublets and like them all. This garden is fortunate in having a variety of species and variants that flower at different times, creating a succession of interest wherever they are.

Finally, one of the most charming spots in the rock garden is a clump of our native dwarf blueberry, *Vaccinium angustifolium*. Through all the seasons it is attractive. I especially enjoy the masses of small white bells which in turn produce quantities of fruit. They never fully ripen because the ever watchful chipmunks get them long before this can happen. In the nearly ten years I have grown this patch I have never been able to beat these varmints to a single ripe berry!

Sources of Plant Material

It has been said that there are two basic types of successful nurserymen: those who sell a great many very ordinary plants to a great many ordinary gardeners, and those who sell very rare and intriguing plants to the discriminating specialist gardener. Those listed below fall in the latter category. There are others, of course.

Alpenglow Gardens, Michaud & Co., 13328 King George Highway, Surrey, B.C. Canada.
Bovee's Nursery, 1737 S.W. Coronado, Portland, Oregon 97219
Greer Gardens, 1280 Goodpasture Island Road, Eugene, Oregon 97401
Edgar L. Kline, 17495 S.W. Bryant Road, Lake Grove, Oregon 97034 (wholesale)
Lamb Nurseries, E. 101 Sharp Ave., Spokane, Washington 99202
Oakhill Gardens, Rt. 3, Box 87, Dallas, Oregon 97338 (Sempervivums and sedums)
Oliver Nursery, 1159 Bronson Road, Fairfield, Conn. 06430
The Rock Garden, Litchfield-Hallowell Road, Litchfield, Maine 04350
Siskiyou Rare Plant Nursery, 522 Franquette Street, Medford, Oregon 97501
Weston Nurseries, East Main Street, Route 135, Hopkinton, Mass. 01748
The Wild Garden, Box 487, Bothell, Washington 98011

The American Rock Garden Society, 90 Pierpont Road, Waterbury, Connecticut 06705. This organization issues annually a very large and comprehensive list of seeds available to its members.

Left: Anemone pulsatilla
Above right: Sanguinaria canadensis. *Photos: G. Pride.*

Scilla tubergeniana. *Photo: P. Chvany.*

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All good rock gardeners should be members of the American Rock Garden Society in order to receive their very valuable publications. The true connoisseur also joins the Alpine Garden Society of the British Isles and the Scottish Rock Garden Society.

Winter Blooming Shrubs

by Richard E. Weaver, Jr.

Winters in the eastern part of this country south of Washington, D.C. are seldom as unpleasant as they are here in the Northeast. Of course the temperatures there are less extreme, but for those of us who appreciate plants and flowers, the real difference is perhaps due to the Camellias. Blooming through the worst weather that January and February have to offer, these wonderful plants with their bright and showy blooms make winter something almost worth anticipating.

Although there are some hopeful new developments through concentrated breeding efforts, we in most of the Northeast still must do without Camellias in our gardens. Nevertheless, there are a surprising number of hardy shrubs, perhaps less showy but still charming and attractive, that will bloom for us through the winter and the early days of spring. Some, such as the Witch Hazels, are foolproof; others present a challenge for they are susceptible to our capricious winters and may lose their opening flowers to a cold March. For those gardeners willing to take the chance, a few of the best early-flowering shrubs displayed in the border, or as the focal point in a winter garden, will help to soften the harshness of the season.

Many plants that bloom in the early spring have their flowers perfectly formed by the previous fall. Certain of these do not require a period of cold dormancy, and in mild climates will flower intermittently during the fall and winter. Most species, however, do require an environmental stimulus, usually a period of cold temperatures, before the buds will break and the flowers open. Occasionally these species will bloom in the fall, particularly if there has been a sharp drought during the summer, followed by a cool, wet period during the early autumn. The very early blooming shrubs discussed in this article are particularly prone to this abnormal fall flowering, and the expanded or partially expanded flowers are invariably frozen later, substantially diminishing their spring display.

Although the flowers of all of the species discussed here can withstand temperatures below freezing, they will be destroyed by extreme cold. In my experience, the flowers, except for those of the species that normally flower during the very cold months, will be nipped when the temperatures fall much below 20° F; those of several species will not take temperatures even this low. Therefore for best bloom, these latter early-blooming shrubs should be planted in a cold micro-

Rhododendron mucronulatum. *Photo: E. H. Wilson, 1923.*

climate, such as an area of the yard that is somewhat shaded during the winter. Blooming then will be slightly delayed, reducing the chances that the flowers will be destroyed by cold temperatures in the spring, even though somewhat defeating the objective of having early-blooming plants. Alternatively, a spot by a sunny wall, or on the south side of a house, should be selected. Here bloom will come early, but air temperatures will be modified by the wall, again reducing the chances of having the flowers nipped. The latter exposure is preferable, particularly for those species that are somewhat tender, as well as for those that do not bloom well in shade.

The following plants are ones that can be expected to begin blooming before the end of March, or by the first week in April at the latest. All are hardy in Zone 5 except where noted. The list is not an exhaustive one; a few other shrubs sometimes bloom early enough to be included, for example the Shadbushes (*Amelanchier* spp.), the Cornelian Cherries (*Cornus mas* and *C. officinalis*) and Forsythias (especially *F. ovata*), but these have already been discussed in detail in recent *Arnoldia* articles and need not be repeated here. The arrangement of the plants is more or less by their order of bloom.

***Hamamelis* — Witch Hazel**

The Witch Hazels are the premier winter-blooming trees and shrubs for northern areas of the United States. I have already discussed them in a recent article (see references), so their treatment here will be brief. The winter of 1976–1977 has been characterized by prolonged periods of cold weather, and the blooming time of the Witch Hazels has been delayed. Some plants of *Hamamelis virginiana*, our native species, were still in full bloom in early December, but abnormally cold temperatures during the first week of the month destroyed the flowers. Then a warming trend brought the Ozark Witch Hazel (*H. vernalis*) into partial bloom at least two weeks ahead of schedule. Very cold temperatures during the rest of December, all of January, and early February did not damage the partially expanded flowers of this species, but further bloom was delayed, and the plants were not in full flower here until the last week of February, a month or more late. *Hamamelis mollis* and the cultivars of *H.* × *intermedia* were also somewhat delayed. The former usually flowers here about the end of January, but this year the petals were not fully expanded until the end of February. Our wonderful specimen of *H.* × *intermedia* 'Arnold Promise' next to the Administration Building usually delights us with its profuse bloom in mid-February. As of this writing (1 March), the petals of its bright yellow flowers are just visible. We will be patient and will be rewarded, but this winter, more than most others, the touch of color the Witch Hazels usually provide would have been welcome a bit earlier.

Left: Chimonanthus praecox, *taken from* Curtis's Botanical Magazine, *vol. 13, plate 466.*

Right: Jasminum nudiflorum, *taken from* Botanical Register, *vol. 32, plate 48.*

***Jasminum nudiflorum* — Winter Jasmine**

This native of China is a member of the Olive family, and its bright yellow flowers appearing on leafless branches suggest those of *Forsythia*, a much more familiar plant of the same family. Flowers of Winter Jasmine have six corolla lobes ("petals") instead of four, however. The sessile (stalkless) flowers, often nearly an inch across, are borne in pairs along the slender, green branches, beginning as early as mid-January in mild winters. The species is marginally hardy in the Boston area, although it is the hardiest of the true Jasmines, and it often does not bloom freely here unless it is grown in a sheltered spot. The plant itself is somewhat of a scrambler, with long, flexible branches. Because of its growth habit, and its unreliable hardiness, the Winter Jasmine is best grown against a sunny wall. It will have to be supported, however, because the plant is not actually a climber.

***Chimonanthus praecox* — Wintersweet**

The common name of this Chinese native is well chosen, since its spicy fragrant flowers appear during the dead of winter. The shrub is not a familiar one in this country, and indeed it is virtually unknown to New England gardeners since it is hardy only into Zone 7. It blooms reliably in Philadelphia, but even there the flowers often suffer from exposure to wind and snow, and the plant is best grown in a sheltered spot.

Wintersweet is a relative of *Calycanthus*, our familiar Sweet Shrub or Carolina Allspice, and the flowers of the two are similar in overall structure. Those of the Wintersweet, however, are usually only about an inch across, and the fifteen to twenty petal-like segments are a translucent yellow, the innermost ones heavily streaked and blotched with purple. Several varieties with slightly different flowers are occasionally encountered. *Chimonanthus praecox* var. *grandiflorus* has flowers almost twice the size of those of the typical plant, but they are only slightly fragrant. The flowers of the var. *concolor* (var. *luteus*) are entirely yellow, and they often are sparingly produced.

Although cultivated in Japan for centuries, the Wintersweet did not reach Western gardens until the middle of the Eighteenth Century. In our gardens it forms a much-branched shrub as tall as 10 feet. The leathery but deciduous, prominently veined leaves are opposite on the twigs, and lance-shaped to oval in outline.

Like most of the winter-flowering shrubs mentioned here, the Wintersweet is not a showy plant. The flowers are perhaps more unusual than beautiful, and they are best appreciated close at hand where their wonderful fragrance is evident.

***Erica* — Heath**

This genus, from whose name are derived the Latin and common names of a large and horticulturally important family of plants, includes several species and hybrids that are among the most charming additions to the list of winter-blooming shrubs. These are also low in stature, with finely-textured foliage, enabling them to be used effectively as complements both to the early spring bulbs as well as the taller shrubs that are the nucleus of the winter garden.

Although a number of *Erica* species grow to be trees, the hardy species, and particularly those included here, are low or even almost prostrate shrubs. The descriptions that follow pertain to the winter-flowering plants. The leaves are basically needle-like, spreading in whorls of four around the branches. The flowers are produced on the upper part of the branches, forming one-sided "spikes." The flowers themselves, about ¼ inch long, are narrowly bell-shaped or cylindric, with the brown to nearly black anthers protruding and conspicuously contrasting with the white to pink or purplish corollas.

Erica carnea *vars. and dwarf* Cryptomeria *at University of Washington Arboretum, Seattle, Washington. Photo: D. Wyman.*

Heaths grow and bloom well in full sun or partial shade. Like all members of their family, they prefer acid soils; Heaths evidently will flourish also in soils that are nearly neutral. The plants discussed below are perfectly hardy, but the bloom is apt to be more reliable and earlier if the plants are protected by pine boughs during the coldest months.

The hardiest species is *Erica carnea*, a native of the mountains of south-central Europe. Most cultivated forms of this species are very low growing with spreading branches, and they make a fine ground cover. The flowers of the wild plant are pale pink, but numerous cultivars have appeared with flowers ranging from pure white to deep reddish. The most commonly available winter-flowering cultivars are described below. In all of these, the flower buds are large and conspicuous by the beginning of the winter. Depending on the weather, they may open as early as January, but even if covered with snow the plants are usually in bloom by early March. Blooming continues for more than a month afterwards.

'King George' — Foliage dark green; flowers deep rose-pink with purple-black anthers; flowers freely produced on short spikes.

Erica carnea, *taken from* Curtis's Botanical Magazine, *vol. 1, plate 11.*

'Springwood Pink' — Foliage midgreen; flowers nearly white, gradually changing to clear pink; vigorous, spreading, and free-flowering.

'Springwood White' — Foliage bright green; flowers white with brown anthers; vigorous and spreading with long spikes of flowers.

The plant known as *Erica* × *darleyensis* is probably a hybrid between *E. carnea* and the tender *E. mediterranea.* The flowers are similar to those of the first species, but the plants are more upright in growth, sometimes attaining a height of 18 inches. Although perfectly root hardy in Zone 5, cultivars of *E.* × *darleyensis* may suffer some winter damage here, and the blooming may not be profuse without the protection of a snow cover or a light mulch during the coldest months. This hybrid is represented by the following readily obtainable cultivars.

'Arthur Johnson' — Foliage light green; flowers mauve-pink in very long spikes, and therefore useful for cutting.

'Silberschmelze' — Foliage dark green; flowers pure white with brown anthers; free-flowering, and forming a neatly rounded plant.

Daphne mezereum (*left*) *and* D. m. *forma* alba (*right*).

Daphne mezereum **— February Daphne**

Although this delightful plant does not flower here as early as its common name implies, it can be relied upon to brighten our shrub borders from the last half of March through much of April. Besides providing welcome color during the drab first days of spring, the flowers are extremely fragrant, and they are followed in the late summer by brightly colored fruits.

The flowers are borne profusely in small clusters directly on the branches. Although they originally appear long before the leaves, some flowers may persist until the leaves are in evidence. The blooms are a bit unusual in that what appear to be petals are actually four colored sepals united into a tube. Their color is typically a dull pinkish-purple, but a whitish variant (*Daphne mezereum* forma

alba) is occasionally encountered both in the wild and in cultivation. The pink flowered plants produce bright red fruits in August and September while the white-flowered ones bear yellow fruits. The plants grow slowly to a maximum of 3 to 4 feet, and seldom need pruning, and they flower well even when grown in the shade.

Several very fine cultivars are grown in Europe, and if introduced into this country could greatly enhance the appeal of an already most desirable plant. They include: 'Paul's White' or 'Bowle's White', with pure white flowers; 'Grandiflora' ('Autumnalis') with larger flowers which, at least in England, appear from October through February; 'Rubra', with reddish-purple flowers; and 'Plena', with double white flowers.

Individuals of many *Daphne* species, including this one, have the disconcerting habit of flourishing for years and then suddenly dying for no apparent reason. Several explanations for this phenomenon have been offered, but none appears to be satisfactory. When conditions are just right, however, *D. mezereum* prospers, as evidenced by the fact that this native of Europe and Siberia has become naturalized several places in the United States and Canada.

Presumably because of their fleshy roots, Daphnes have a reputation for being difficult to transplant. However, by moving them in the spring and keeping them moist well into growth, I have not encountered problems, even with fairly large individuals.

It must be pointed out that all parts of the plants of *Daphne* species contain seriously poisonous compounds. They are basically attractive to children only when in fruit, so that danger of poisoning may be greatly reduced by removing the "berries" before they ripen.

Corylus — Hazelnuts

All of the Hazels bloom early in the spring, before the leaves have expanded. The plants are monoecious; that is, with separate pistillate ("female") and staminate ("male") flowers borne on the same individual. The pistillate flowers are inconspicuous, obvious at all only because of the feathery red styles protruding from what merely appear to be buds. The staminate flowers are borne in long pendulous catkins that are in evidence throughout the winter. Usually during the last half of March, they elongate and open, exposing the yellow anthers and pollen. In many species the catkins are borne profusely. Although not exactly showy even then, the catkins are conspicuous and delicately beautiful, and the aspect of the plant is certainly pleasing. The familiar nuts, which ripen in midsummer, are an added bonus for growing these plants.

Perhaps fifteen species of *Corylus* are in cultivation, but only one will be singled out here. Selected clones of the European Hazelnut, *C. avellana*, are the primary source of the commercial Hazelnuts, and this species is one of the most attractive in flower. The catkins

Corylus avellana. *Photo: H. Howard.*

of this species, which is native through much of Europe, western Asia and northern Africa, are often as much as 2½ inches long and are borne in profusion. Two cultivars are particularly desirable because their growth habit adds greatly to their winter interest.

Corylus avellana 'Contorta', the original plant of which was found in an English hedgerow in 1863, is certainly among the best of a class of rather bizarre plants cultivated for their twisted and contorted branches. A mature specimen of this plant is striking indeed, particularly in flower, with the vertically oriented catkins set off against the network of intricately twisted branches and twigs. It is available from a number of nurseries as "Harry Lauder's Walking Stick," this picturesque name referring to the familiar prop of a famous Scottish performer of an era before mine. The plant is slow-growing, with the ultimate size perhaps 8 feet tall with a spread of 10 feet.

Much rarer in cultivation, *Corylus avellana* 'Pendula' is also a desirable ornamental. The branches of this shrub are stiffly drooping, forming a symmetrical, mound-shaped specimen at maturity. This clone is occasionally grafted onto a standard. Although I have never seen a specimen grown in this manner, the result, somewhat formal, should be most attractive.

Salix — Willow

The genus *Salix* is a large one, with a wide geographic distribution, and it includes plants of greatly varying habit, from large trees to prostrate shrublets. All of the species, however, are dioecious; that is, with separate male and female individuals, as in Hollies. The flowers themselves are minute and greatly reduced in structure; the males consisting basically of only stamens, and the females of a single pistil. Each is surrounded at the base by a scale-like structure that is often densely hairy. The flowers are grouped into clusters of a type known as catkins. Those species with silky-hairy flower scales and dense, compact catkins are commonly known as Pussy Willows. These are among the most ornamental of the Willows, and they are among our best-loved harbingers of spring.

A few of the species with the earliest and most ornamental catkins are included in this article. Even with the unusually cold weather this winter, the catkins of most of these were in evidence by the first of March, even though the plants are not yet technically in flower. In all Pussy Willows the male plants are more desirable horticulturally than the females because they are more attractive in bloom. The slender yellow or reddish stamens provide a pleasing contrast with the pearly gray of the rest of the catkin, and they are more conspicuous than the stubby, green pistils of the female flowers.

The male catkins also are often denser and more compact than are the females.

If the plants are pruned back annually and generously fertilized, the new growth will be vigorous, unbranched, and floriferous. This provides good material for indoor arrangements; the branches sold in florist shops are the result of these cultural methods. Vigorous annual pruning also reduces the damage from the boring insects to which many species are so attractive.

The Pussy Willows available in the nursery trade are often hybrids of obscure origin. The following species are prominent in the parentage of many of these hybrids, but they are ornamental in their own right.

Salix caprea, the Goat Willow, a native plant through much of Europe and northeastern Asia, is perhaps the best known species. It responds well to heavy pruning, producing sturdy branches with darkish gray catkins almost 1½ inch long; if not pruned back it will form a bushy tree as much as 25 feet tall. It is quite susceptible to borers.

The Daphne Willow (*Salix daphnoides*) is a native of Central Asia and the Himalayas. It is less well known than the preceding species, but is resistant to borers and considerably more ornamental. As the catkins emerge they are almost white, and contrasted against the red-bronze twigs, they are exquisite. When fully expanded they are about an inch long, soft pearly-gray, and very silky.

Salix gracilistyla is a beautiful Pussy Willow from Japan, Korea, and adjacent China. Unlike the two preceding species, this one is definitely shrubby, seldom growing taller than 10 feet. The pale silvery catkins are different from the preceding in that they are more or less cylindrical in shape; that is, distinctly longer than broad. This is one of the earliest flowering Pussy Willows.

The last "species" to be discussed here is a most distinctive Willow and one that has only recently become commercially available in this country. Its correct name, and its origin, are somewhat of a problem. It has passed as a variety of the preceding species, but it differs from *Salix gracilistyla* in a number of important technical characters, and it has never been found in the wild. It has been in cultivation in Japan for some time, and is perhaps a hybrid. For the time being at least we will call this Willow *Salix melanostachys*.

The most outstanding feature of this plant is its black catkins. Although they are only about ½ inch long, they are abundantly produced, and their color is truly striking, particularly with their brick red anthers which finally turn to yellow as they mature. Only the male form of this shrubby plant has ever been found. Those readers who are members of the Friends of the Arnold Arboretum can look forward to receiving a plant of this outstanding Willow in the spring of 1978 — barring crop failure, of course.

***Lonicera* — Honeysuckle**

Two closely related Chinese species of this large and varied genus, as well as the hybrid between them, are indispensable additions to the winter garden. *Lonicera fragrantissima, L. standishii*, and their hybrid *L.* × *purpusii* (the last having appeared spontaneously in the botanical garden at Darmstadt, Germany), differ primarily in characters of foliage and pubescence. They are nearly equivalent from a horticultural standpoint, so they will be considered collectively here. It must be pointed out, however, that only *L. fragrantissima* is generally available in this country.

The Winter Honeysuckles form more or less erect shrubs with an ultimate height of approximately 6 feet. Their bark is pale brown with a papery texture and a somewhat ragged appearance. They are evergreen in mild climates, but in New England they are completely deciduous. As implied by the Latin name of the commoner species, the flowers of these plants are exceptionally fragrant. The fragrance is distinctive and pleasant, spicy with a hint of lemon.

If the buds are not injured by frosts in the early autumn, or by extreme cold in March, the ¾-inch, translucent white flowers with their projecting yellow stamens begin to appear in Boston just as

winter technically ends. In good years the bloom is generous, but the shrubs are never by any means "covered with flowers." The Winter Honeysuckles are excellent for cutting, and branches can be easily forced into bloom as early as January. In the home, close at hand, the delicate flowers with their wonderful fragrance are much more charming than Forsythias could ever be.

Viburnum

The genus *Viburnum* includes a large number of plants of outstanding horticultural value. Many species are ornamental in flower, fruit, and autumn color, so they are exceptionally versatile in the garden. The versatility of the genus is further enhanced by the flowering periods of the various species that span almost the entire year. *Viburnum farreri* (formerly *V. fragrans*) blooms early enough in New England to be included in the winter garden. Here this native of China produces a generous display of intensely fragrant, pink tubular flowers in roundish clusters before the end of March in good years. In milder climates, the flowers appear intermittently during the fall and winter, and not infrequently here at the Arnold Arboretum a few will open just in time to be nipped by the first frost. The foliage appears quite early and remains in good condition during the growing season, taking on a bronzy tint during the summer and finally turning maroon in the fall.

Several variants of the species are in cultivation. *Viburnum farreri* var. *album* has pure white flowers that are slightly larger than those of the typical plant, and they also appear perhaps a week earlier. The cultivar 'Bowles' has deeper pink flowers.

Viburnum × *bodnantense*, a hybrid between this species and the tender *V. grandiflorum*, has been produced several times. A selection from the cross that was made at the famous Bodnant Gardens in Wales has been given the cultivar name 'Dawn'; this is the clone now in general cultivation. This plant is a better garden plant than either of its parents for us in the Northeast. It blooms slightly later and more profusely than *V. farreri*; the flower clusters are looser, and the flowers themselves are deep pink in bud but fading to a blush as they mature.

Rhododendron

March is hardly a month when most New Englanders start to look for Rhododendrons and Azaleas in bloom. However, two closely related species can be counted on to add a splash of color to the drab landscape before the month is out. The color of the blossoms of both species is typically lavender to rose-purple, colors that many people find objectionable in flowers; but at this time of year, who can be choosy?

Lonicera standishii. *Photo: H. Howard.*

Viburnum farreri *var.* album. *Photo: D. Wyman.*

The difference between Rhododendrons and Azaleas is often a point of confusion, and this is not the place to enter into a taxonomic discussion. Both types of plants are generally classified botanically in the genus *Rhododendron*, but as distinct subgenera. The species discussed here are technically Rhododendrons, even though they are usually deciduous and would easily pass as Azaleas to the non-botanist.

Rhododendron dauricum, the Dahurian Rhododendron, is the first of its genus to bloom in New England. The flowers, 1 to 1½ inches across, from clustered buds near the ends of the branches, generally begin to appear during the last week of March. Typically the small leaves are deciduous in the fall, but var. *sempervirens* is partially evergreen even in our climate. This species is horticulturally less desirable than the following, and it is not commonly grown. It is perhaps best known indirectly, since the evergreen variety is one of the parents of the increasingly more popular PJM Hybrids.

The Korean Rhododendron, *Rhododendron mucronulatum*, is a first-class garden plant. It is vigorous, hardy, and floriferous, perhaps the showiest of the early-blooming shrubs. It is completely deciduous, and the flowers usually appear at the very end of March, long before the leaves which might hide their glory. The species, growing as tall as 6 to 8 feet, is widely distributed throughout northeastern Asia, and the flower color is variable both in the wild and in cultivation. Most commonly, the 1½- to 2-inch, widely open blooms are a pale rosy-purple; several darker flowered variants have been named, but they are not yet commonly available. A clear pink-flowered seedling appeared among a population grown by Mr. Henry Skinner at Cornell University in the 1930's; this selection, named 'Cornell Pink', is now widely distributed, offering an attractive alternative for those people who do not like the flower color of the typical plant. A white-flowered variant (forma *albiflorum*) has been found in Korea, but it is not yet widely known in cultivation. Another series of variants recently discovered at high elevations in Korea may eventually lead to the development of dwarf forms of exceptional horticultural merit.

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Rhododendron dauricum. *Photo: H. Howard.*

Storm Damage

by Gary L. Koller

This winter, storms with rapidly dropping temperatures, great snow accumulations and winds fluctuating from gentle to severe struck much of the Northeast. These conditions will cause the 1976–77 season to be long remembered for the discomfort and inconvenience caused to people across the nation. What may be overlooked or forgotten is the effect this winter phenomenon had on plant life.

In late autumn, Boston temperatures dropped quickly and hovered around zero. Although not dramatic, it was unusual for cold weather to arrive so early with a lack of snow to insulate and protect the soil. This allowed quick and deep penetration of frost into the ground and it struck the plants before they were fully acclimated to the full brunt of winter. Such a combination is particularly harmful to newly planted, semi-anchored plants as well as those marginally hardy specimens that are the delight of avid gardeners. Those who were wise and energetic applied a deep mulch in order to slow frost penetration and extend the growing season in the root zone. This one effort may have saved many fragile specimens.

On the 7th of January, Boston was struck by a snow storm that deposited 15.4 inches of snow in a 24-hour period. Even though the wind velocity was relatively low and there was little ice accumulation, many trees and shrubs suffered great structural damage. This resulted from the build-up of snow in the dense, twiggy branch structure which allowed ever increasing amounts to accumulate. Plants are remarkable in the stress they can endure, but the tremendous weight along with the occasional gusts of wind overcame their endurance and resulted in split crotches, sheared off branches, shattered limbs, and bent and twisted shapes.

At the Arboretum, minor damage affected specimens in all areas; however, in the area from the Administration Building to Bussey Hill damage was severe on the following plants or plant groups:

Acer sp.
Amelanchier sp.
Betula sp.
Celtis sp.
Cornus florida
Maackia sp.
Magnolia × *soulangeana*
M. virginiana

Oxydendron arboreum
Pinus strobus
Robinia sp.
Sophora japonica
Syringa sp.
Tilia cordata
Ulmus sp.

It saddens one to see stately specimens fifty to seventy-five years old ruined so quickly. In some instances a severely damaged plant represented our only specimen of a particular taxon. *Maackia chinesis*, for example, was full and picturesque and is now gaunt and pathetic looking. Its present appearance does not do justice to the species; however, this specimen cannot be removed until it is propagated and replaced. So it remains, attesting to the brutality of nature.

Visitors occasionally remark about broken stubs or large wounds on Arboretum plants and regard them as poor maintenance. What is overlooked is the fact that our maintenance staff gets so little help from the New England climate. Further south, winter snow and ice storms are infrequent and less severe, allowing gardens to display a larger percentage of perfect specimens. In the light of our problems, our plants are well maintained in terms of good arboriculture practices.

The positive approach to storm-damaged trees is not to lament the loss of a majestic specimen that cannot be restored to its former splendor; instead, the plant must be evaluated for the potential development of new artistic beauty or enhanced character, which can be by-products of breakage. Examples are the magnificent and stately white pines of New England that show the ravages of many storms, yet add a distinct flavor to the New England landscape.

Examples follow of some of the types of damage suffered by the Arboretum's collection this winter, along with remedial measures taken by our maintenance staff.

Long branches with insufficient girth have split from the weight of heavy ice and snow. Such damage can be reduced by occasional preventative thinning of the canopy.

The injured branch should be cut back to a large lateral limb, or to the trunk. On rare and valuable trees, fresh wounds sometimes can be pulled together, secured with bolts, and covered with grafting wax. Natural grafting will ultimately unite the tissue, but the branch will remain structurally weak. As a precaution against further injuries, thinning of the terminal end will be necessary. All photos: G. Koller.

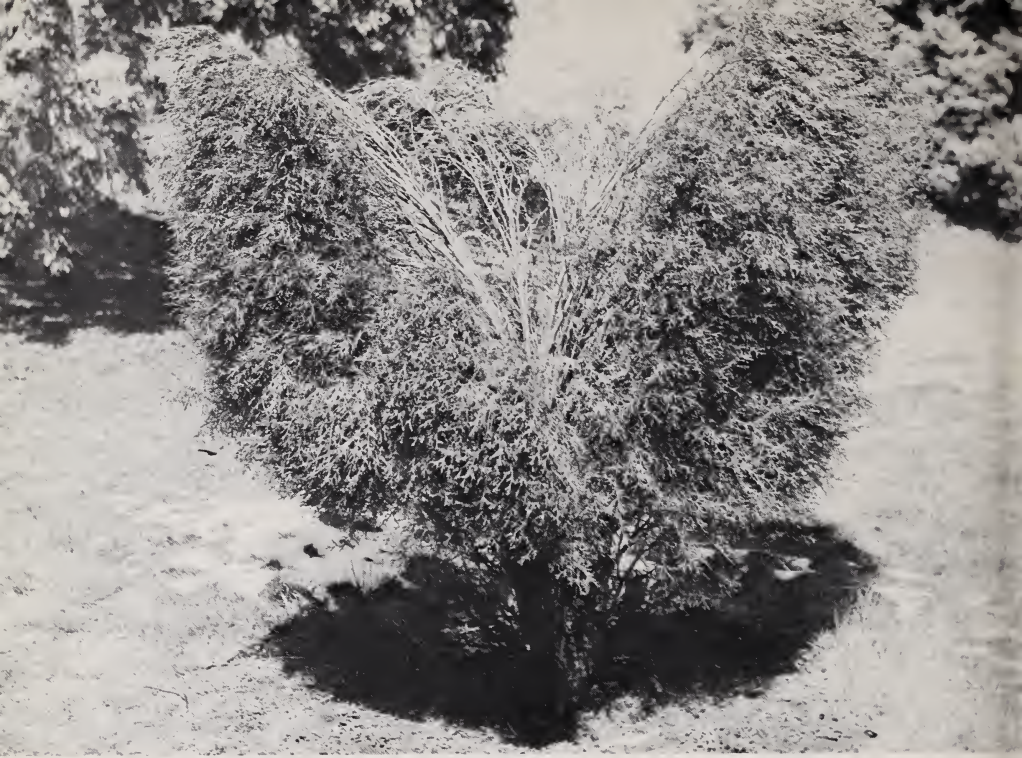
Split crotches result when increasing stem girth and opposing canopy weight cause stress on narrow crotch angles, creating a structural weakness susceptible to storm damage.

Preventative measures should begin early. In choosing small trees, avoid those with narrow, V-shaped crotches. Trees in your yard with this flaw should have their branches pruned flush with the crotch; the wounds will heal quickly and new branches soon will fill out the symmetry of the plant.

Structural weakness caused by years of stress made this crotch a prime candidate for winter storm damage.

Note the dark area at the upper edge of the wound. This indicates that a cleft due to physical stress had begun, along with disease-associated deterioration. Heavy snows, added to the existing stress, caused the limb to be ripped away at the crotch.

Once damage has occurred, the injured branch should be pruned flush with the trunk, and the ragged edges of the wound made as smooth as possible. Eliminate hollow areas that might trap and hold water, fostering the growth of disease organisms. Painting large wounds with tree paint is primarily cosmetic.



Left: Ice, snow, and wind can bend or twist structurally weak plants, sometimes causing a permanent change in configuration or irreparable breakage. In early autumn, susceptible plants should be staked, bound together with lacing, or covered with burlap to prevent or minimize damage.

If possible, accumulated heavy snow should be brushed off gently. Ice and crusted snow tends to cling to branches and foliage, and wood can be brittle when temperatures are low and external stress is great. Once damage has occurred, bent plants must be staked, sometimes permanently. Plants with flayed-out branches must be pulled back into their normal shape and belted or cabled into place.

Stripped bark, often the result of storm damage, also frequently results from incorrect pruning practices or mechanical damage from automobiles and grounds-care equipment. The large wounds that may occur are difficult or impossible for the tree to cover with protective bark.

If the injury is fresh and the flap of stripped bark is partially attached, the injured branch may be pruned away and the bark flap often can be pushed back into place and secured with nails. Exposed edges should be covered with grafting wax or wrapped with moist sphagnum moss. Natural grafting should result.

Plant Names. T. S. Lindsay. Detroit: Gale Research Company. viii and 93 pages. $8.00.

This book, first published in 1923, begins with the premise that there is an unreasonable prejudice against the use of scientific plant names and that if the author's fellow gardeners could understand the meanings of "those long, weird" Latin names, they would remember the names more readily. His introductory chapters give a very good defense for the more widespread use of Latin binomials of garden plants, and a brief history of plant naming. However, the discussion of current principles and rules of nomenclature is out-dated. Since 1923, the International Botanical Congress has published several revisions of its Code of Botanical Nomenclature and there are other books which more clearly interpret this code for the non-botanist. The remaining chapters of this book consist of lists of plant names and their meanings organized in rather arbitrary, whimsical groups. Emphasis is on popular British garden plants.

Anyone who knows garden plants by either common or scientific names may be interested to know how these names came to be and what their meanings signify. Much of this fascinating and amusing information is presented; however, throughout the book, common and scientific names are treated equally and no clear distinction between them is made. This could only be confusing to anyone interested in learning the correct names for plants.

Ida Burch

The Complete Handbook of Plant Propagation. R. C. M. Wright. New York: Macmillan Co. 191 pages, illustrated. American edition. $12.95.

The preface indicates that the original publication was titled "Plant Propagation" and was favorably received. This first American edition is of the revised British edition and should be received with favor. The volume is attractive, with excellent color and black and white photographs, and many drawings. Twenty-three chapters from general principles to pests and diseases in relation to propagation offer encyclopedic coverage. This will meet the requirement for a single volume on plant propagation for the home owner who has trees, shrubs, annuals and perennials, vegetables, and even aquatics. It could serve well as a textbook in courses in horticulture. Seven pages of four columns, and over fifty entries in each column comprise a good index and indicate the coverage of this volume.

Richard A. Howard

Historic Virginia Gardens. Preservations by the Garden Club of Virginia. Dorothy Hunt Williams. Charlottesville, Virginia: The University Press of Virginia. 350 pages, illustrated. $20.00.

This moderately expensive book is an account of the efforts of the Garden Club of Virginia over approximately a fifty-year span (from 1928 through the early 1970's) to restore and preserve twenty-two gardens of historic interest in Virginia. It is interesting to note that the financing for this enormous project was initially accomplished by a statewide tour of private homes and gardens, with the proceeds used to finance the restorations. Admission fees to the restored gardens have made the endeavor self-perpetuating.

The author details specific problems of each restoration in addition to a physical and historic description of each garden. Reproductions (some not too readable) of the documents, plans, and illustrations used in the restorations and many excellent pictures, some in color, comprise a large portion of the book. Lists of the plant materials used in each garden are also included.

This book might have specific appeal to the student of landscape architecture or to an individual (or group) contemplating restoration of an old garden. It also offers the traveling gardener (including the armchair variety) a chance to acquaint himself with Virginia's superb garden heritage.

B. June Hutchinson

The Trees Around Us. Peter Barber and C. E. Lucas Phillips. London: Weidenfeld and Nicolson. 191 pages, illustrated. £8.50.

"Our purpose in this book will be to make a wide ranging survey of the trees of the Temperate Zones and to select from among them those that can most profitably be put to use for man's delight. We do so as a contribution to those movements, so far all too weak, that aim to bring home to men's minds the social and aesthetic consequences of the wastage and neglect of the trees around us and to stir those in authority to more effective action."

The authors accomplish this tastefully and effectively by first telling of the relation of trees to their environment — soil, wind, salt spray, temperatures, sun and shade; of their use in landscaping from private gardens to city planning projects; and how to transplant and prune them. The remaining and largest part of the book is a register of "the majority of the ornamental trees that can be successfully grown in the Northern Temperate Zone." This register is both more and less than a manual. More because it provides lore, word origins, historical items, horticultural uses, and aesthetic values; and less because the taxonomic descriptions are sprinkled in rather informally. The illustrations are a combination of black and white and color photos and excellent line drawings for identification.

Highly readable, it will be of interest to all, amateur or professional, novice or expert, British or non-British.

Richard Warren

Wildflowers of Eastern America. John E. Klimas and James A. Cunningham. New York: Alfred A. Knopf. 273 pages, illustrated. $17.95.

The excellent format, fine paper and marvelous plates immediately identified this book as of foreign origin. Planned by the Chanticleer Press of the United States, it was printed in Italy and is of fine quality indeed.

This work is intended as a field guide and uses a dichotomous key based upon flower color. The book commences with a very brief exposition of botanical nomenclature, including useful line drawings of plant parts. There is an excellent glossary at the beginning, where it belongs, rather than at the end.

Because the photographs, all good, were selected from so many sources, the scale of various plants is inconsistent from one photo to another and this is one major flaw in the book. A second, smaller, drawback is that the common name accompanies each photograph, leaving us to search the text or the excellent index for the botanical name.

In general, this is a truly delightful and useful work. Because of its expense, however, many of us will have to consult it in the library, rather than at home or in the field.

Wildflowers of Western America. Robert T. Orr and Margaret C. Orr. New York: Alfred A. Knopf. 270 pages, illustrated. $17.95.

How the writer would have treasured this on a recent visit to the Rocky Mountains! The authors are professional biologists and they emphasize the uses of wild plants in their contemporary, ecological, medical and other contexts. The editorial style is particularly agreeable. It flows naturally and reads as the work of enthusiasts rather than sentimentalists.

The photographs are excellent and the plants are shown as one might actually see them — on one's knees, combing the foliage and searching inquisitively for the elusive blooms. A very instructive and delightful volume.

ELINORE B. TROWBRIDGE

Winter Flowers in Greenhouse and Sun-heated Pit. Kathryn S. Taylor and Edith W. Gregg. New York: Charles Scribner's Sons. 281 pages, illustrated. $4.95.

We welcome this paperback, low priced edition of a well written, informative, enjoyable book. A sun-heated pit greenhouse is within the capabilities of nearly every home owner. It is relatively economical to build, maintain and operate and requires little space. A remarkable variety of plants can be grown. This is a "how to do it" book by experienced authors. Their successes and failures are described with equal enthusiasm and their suggestions and warnings are well founded. An extensive listing of plants for pit and cool greenhouse has the cultural details of what the authors say "has worked for us."

RICHARD A. HOWARD

Sedum of North America North of the Mexican Plateau. R. T. Clausen, drawings by Elfriede Abbe. Ithaca and London: A Comstock Book, Cornell University Press. 742 pages, illustrated. $65.00.

Since 1935 Robert T. Clausen of Cornell University's Wiegand Herbarium has devoted much of his time to the study of the North American species of the taxonomically complex genus *Sedum*. His labors have resulted in two volumes, *Sedum of the Trans-Mexican Volcanic Belt* (Cornell University Press, 1959), and more recently, the book noted here. This latter work, like the first, includes an almost overly detailed and belabored statistical analysis of the thirty native species, while containing material usual in a monographic treatment, viz. keys, descriptions, distributional, cytological, and ecological data, and nomenclatural and biological information. Other sections of the book synthesize geological and geographical data with the evolution and interrelationships of the species. The concluding chapters, moreover, deal with naturalized species and those cultivated but not native in North America. Closely allied genera of the Crassulaceae that occur in North America are also treated.

The volume is beautifully illustrated with line drawings by Elfriede Abbe, which are supplemented by numerous photographs and distribution maps. While botanical libraries and persons with a deep interest in *Sedum* will require this book on their shelves, the price alone will discourage its purchase by those with only a moderate interest in these diverse succulent plants.

STEPHEN A. SPONGBERG

Iris reticulata *'Springtime'. Photo: P. Chvany.*

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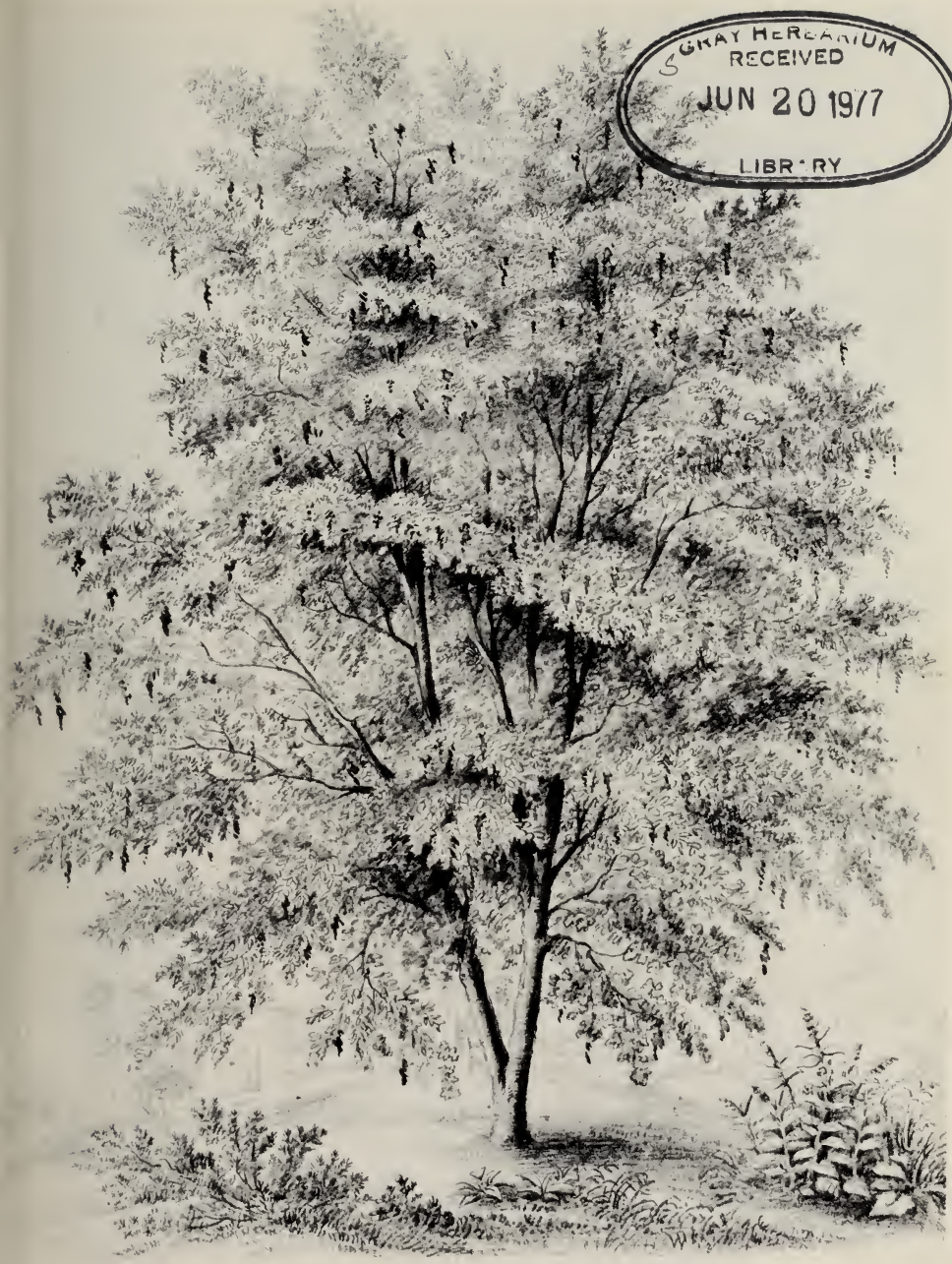

ARNOLDIA

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Cover: Pencil and ink drawing of a flowering tree of Cladrastis lutea *by Anton Hockstein (1829–1911); reproduced with the permission of the Gray Herbarium of Harvard University.*

Cladrastis: the Yellow-Woods

by Kenneth R. Robertson *

A contest held to select the most beautiful flowering tree native to eastern North America (exclusive of southern Florida) would certainly bring forth a number of entrants, each staunchly supported by many admirers. A leading contender for the title would be the evergreen magnolia or bull bay, *Magnolia grandiflora*. The catalpa trees, *Catalpa speciosa* and *C. bignonioides*, would likely be nominated, along with the Franklin-tree, *Franklinia alatamaha*, the black locust, *Robinia pseudoacacia*, the Carolina silverbell, *Halesia carolina*, the sourwood, *Oxydendrum arboreum*, and the tulip-tree, *Liriodendron tulipifera*. A number of small trees would also have to be considered, including the flowering dogwood, *Cornus florida*, the eastern redbud, *Cercis canadensis*, the native crabapples, *Malus* species, the shadbushes, *Amelanchier arborea* and *A. laevis*, and the hawthorns, *Crataegus species*. All of these trees are outstanding ornamentals, being attractive not only when in flower but throughout most of the year, and they are all commonly cultivated in the eastern United States wherever they are hardy.

There is, however, another plant, rare in nature and in cultivation, that is worthy in every respect of being considered one of the most beautiful trees of eastern North America. This is the yellowwood, *Cladrastis lutea*, which was discovered in March of 1796 by André Michaux, as related in his Journal.

"The 2nd remained over in order to pull young shoots of a new Sophera I had remarked in the vicinity of Fleen's Creek about 12 miles from the Fort [Fort Blount, on the north bank of the Cumberland River near the present town of Gainesboro, Tennessee]. Snow covered the ground and I was unable to get any young shoots but Captain Williams, the young [officer] stationed in the Fort, cut down some trees and I found some good seeds.

"I also pulled up some roots of those trees to replant them in my garden in Carolina.

"The same day I had occasion to write to Governor Blount."

I do not know if plants were successfully propagated from these seeds and roots. André Michaux died of a tropical fever in Madagascar in 1802, but his son, François André, who had accompanied his father on many collecting trips in the Carolinas, continued to explore

* Present address: Illinois Natural History Survey, Urbana, Illinois 61801.

the southeastern United States. In the year of his father's death, François also came across yellow-wood trees, as mentioned in his Travels.

"We found particularly, in these forests, a tree which, by the shape of its fruit and the disposition of its leaves, appears to have great affinity with the *Sophora japonica*, the wood of which is used by the Chinese for dyeing yellow. My father, who discovered this tree in 1796, thought that it might be employed for the same use, and become an important object of traffic for the country. He imparted his conjectures to Mr. Blount, then governor of this state, and his letter was inserted in the Gazette at Knoxville on the 15th of March 1796. Several persons in the country having a great desire to know whether it were possible to fix the beautiful yellow which the wood of this tree communicated to the water by the simple infusion, cold, I profited by my stay at Nasheville to send twenty pounds of it to New York, the half of which was remitted to Dr. Mitchell, professor of chemistry, and the other addressed to Paris, to the Board of Agriculture, attached to the Minister of the Interior, in order to verify the degree of utility that might be derived from it. This tree very seldom rises above forty feet, and grows, in preference, on the knobs, species of little hills, where the soil is very rich. Several of the inhabitants have remarked that there is not in the country a single species of tree that produces so great an abundance of sap. The quantity that it supplies exceeds even that of the sugar maple, although the latter is twice its bulk. The epoch of my stay at Nasheville being that when the seeds of this tree were ripe, I gathered a small quantity of them, which I brought over with me, and which have all come up. Several of the plants are at the present moment ten or fifteen inches high. It is very probable that this tree may be reared in France, and that it will endure the cold of our winters, and more so, as, according to what I have been told, the winters are as severe in Tennessee as in any parts of France."

The yellow-wood tree was not included by André Michaux in his posthumously published *Flora boreali-americanae* of 1803. However, his son did describe it in his *Histoire de arbes forestiers de l'Amérique septentrionale* of 1813, naming it *Virgilia lutea*. At that time, the genus *Virgilia* was used for a number of species that had been included previously in *Sophora*. (Today, *Virgilia* is restricted to one or two species of South Africa.) In 1824, C. S. Rafinesque published a new generic name, *Cladrastis*, for this tree, renaming the species *C. tinctoria*. The International Code of Botanical Nomenclature recognizes the principle of priority so that the proper scientific name of a plant is the combination of the earliest available legitimate specific epithet with the correct generic name. For many years, the accepted scientific name of the yellow-wood tree has been *Cladrastis lutea* (Michaux f.) K. Koch. However, Rudd (1971) adopts the name *C. kentukea* (Dum.-Cours.) Rudd. This specific name is based on a description published by Dumont de Courset in 1811 of a young, non-flowering plant cultivated in France. Although the description appears to correspond to the yellow-wood, there are differences, and I am hesitant to accept this name change.

Yellow-wood is a moderate-size deciduous tree, with mature plants reaching a height of 50 feet (Cover, Figures 1 and 4). The trunk,

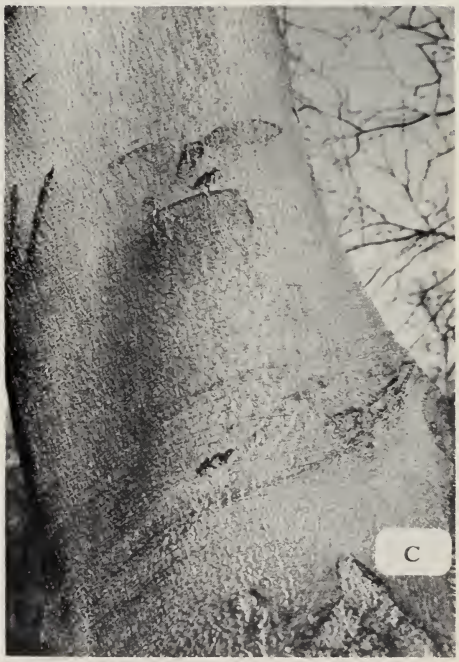

Fig. 1. a–c, Cladrastis lutea *in winter: a, grove of four trees on the Tree Legume slope in the Arnold Arboretum; b, base of tree with short trunk and several main branches; c, smooth, beech-like bark of a main branch. Photos: K. R. Robertson (from colored slides).*

often 2 or 3 feet in diameter, is short and soon forks into a few wide-spreading branches, and the tree has a graceful, broad rounded top. The record tree in Morristown, Pennsylvania is 58 feet tall with a crown spread of 70 feet and a trunk circumference of 16 feet. The heart-wood is a clear yellow when first cut, partly changing to a light brown. The hard, heavy, strong, and close-grained wood takes a good polish, and early pioneers used it to make gunstocks and small articles of furniture. Fortunately for the sake of the species, but not for cabinetmakers, the trunks of wild trees fork too closely to the ground for the species to be harvested commercially for lumber. Also, the wood tends to crack and check unless carefully dried. The bark (Figure 1c) is smooth and silvery-gray, much resembling that of beech trees. As a result, yellow-wood trees in parks and arboreta usually bear the marks of young lovers and others who like to carve their initials on trees. The root system, deep and extensive, does not interfere with neighboring trees or a lawn (although it possibly might clog underground drainage systems) and enables well established yellow-wood trees to endure periods of drought. Branches of the yellow-wood are brittle (the generic name comes from the Greek *klados*, branch, and *thraustos*, fragile), and the crotch of the tree trunks also are weak; thus, yellow-wood trees, particularly old ones, are susceptible to damage by strong winds. Young yellow-wood trees may be pruned to a single upright bole that is considerably more resistant to wind damage.

The winter buds are very distinctive (Figure 2a). They are in superposed clusters of usually three sessile, densely pubescent buds that are nearly encircled by a prominent C- or V-shaped leaf scar (the bud cluster was entirely enclosed by the base of a petiole of the previous year). A true terminal bud is lacking (although the last axillary bud is often produced very near the tip of the twigs) and branching is thus sympodial, with the twigs often being slightly zig-zagged. In midspring, the uppermost bud of the more apical bud clusters (Figure 2b, c) and also some of the lower axillary clusters enlarge and quickly send out the growth of the year. Since the new shoot with its leaves and inflorescence is largely preformed in the winter bud, growth and expansion is quite rapid. Each new shoot on mature trees is only a few inches long and is terminated on flowering branches by the very long inflorescences. The leaves expand to their full size quickly, but the flowers do not open until early summer; thus there is a period of several weeks when the pendulous inflorescences, hanging below the foliage, give yellow-wood trees an unusual, rather graceful appearance (Figure 2d). The leaves of *Cladrastis lutea* are arranged alternately along the branches, are pinnately compound with an odd number, usually seven (five to eleven), of leaflets per leaf, and are mostly 10 to 15 inches long at maturity. The lateral leaflets are broadly elliptic or ovate in outline, with acuminate tips, tapering or slightly rounded bases, and entire margins; the terminal leaflet is more

Fig. 2. Cladrastis. *a–h,* C. lutea: *a, winter twig — note superposed buds surrounded by leaf scar; b, tip of twig in early spring with two leaves and inflorescence emerging; c, branch later in spring with expanding leaves and young inflorescences; d, fully expanded leaves and pendulous inflorescences, the flowers not yet open; e, inflorescence with open flowers; f, lower part of flowering tree; g, large tree in full flower; h, tip of summer twig with bases of two leaves, the base of the leaf to the right pulled away from the twig to show how it encloses the winter buds; i,* Fruits *of* C. platycarpa. *Photos: K. R. Robertson (from colored slides).*

or less rounded-rhomboid in outline with a cuneate base and an abruptly acuminate tip and is shorter and broader than the lateral ones. The upper lateral leaflets are usually 4 to 6 inches long and 2 to 3½ inches wide at maturity, with the lower lateral leaflets being somewhat smaller. A characteristic feature of leaves of *Cladrastis* is that the lateral leaflets are arranged alternately along the rachis of the leaf (Figure 4b). This feature, plus the relatively large size of the leaflets, could cause the casual observer to think that the leaves were simple instead of being compound (the first leaves produced by seedlings are, in fact, simple). Stipules and stipels are absent. In autumn, the leaflets turn a clear bright yellow. As mentioned earlier, the base of the petiole is swollen and completely encloses the winter buds (Figure 2h).

The white flowers, opening in June, are borne in long, many-flowered, pendulous, *Wisteria*-like panicles that terminate the growth of the current year (Figure 2e, f). Flowers are produced in abundance usually only every second or third year, but in a good year, the trees are spectacular! (see Figure 2g.) The papilionaceous (pealike) flowers show that *Cladrastis* is a member of the pea subfamily of the legume family (Leguminosae subfamily Faboideae). The sepals are united into a green tube with five calyx teeth. The five petals are of three different sorts (Figure 3). The upper "banner" petal is outermost and, in bud, encloses the two lateral "wing" petals and the two inner "keel" petals. All the petals are clawed below, and they fit together so that the banner petal, which has a yellow area toward the base of the blade, is very conspicuous and attracts insect pollinators, while the all white wing and keel petals function as a landing platform for insects. The flowers are quite fragrant, particularly in the evening. The ten stamens are enclosed by the keel petals. In *Cladrastis*, the filaments of the stamens are all free from one another. This feature indicates that this genus is allied with *Sophora*, pagoda trees, *Maackia*, and numerous other genera. As in nearly all Leguminosae, the pistil is of one simple carpel. The cylindrical ovary is shortly stalked below and tapers above into an elongate style that is tipped by a small stigma.

The fruit of *Cladrastis lutea* is a flattened legume, somewhat like that of redbud (the genus *Cercis*), up to 4 inches long and mostly ⅜ inch wide (Figure 4c). There are one to several seeds in each fruit, and the fruits are often slightly constricted laterally between the seeds (perhaps the best botanical description would be "flattened tortulose"). The fruits mature in size by August and in September are brown and dry. They remain on the trees for a short period after the fall of the leaves, but they soon fall to the ground. The fruits on the trees, both during the summer and after the leaves have fallen, detract from the appearance of the trees, but at least they do not remain on the trees during winter. After the fruits have fallen to the ground, the fruits either dehisce or they decay over winter to release

Fig. 3. Cladrastis lutea. *Original drawing by C. E. Faxon from which the engraving for* Tab. CXIX *in Vol.* 3 *of Sargent's Silva was made. Shown in the illustration are: a flowering branch, the petals of a flower (lower left), a diagram of a flower, a stamen, a vertical section of a flower and an ovary, and an ovule (all to the lower right). From the Library of the Arnold Arboretum.*

Fig. 4. Cladrastis lutea. *a, grove of trees on Tree Legume slope in summer; b, mature leaves; c, fruit. Photos: K. R. Robertson.*

the seeds. The seeds are olive-brown and beanlike, slightly laterally flattened, and about ¼ inch long and ⅛ inch wide; the hilum is quite off-center.

Cladrastis lutea is endemic to the eastern United States, occurring from Brown County, Ohio and Brown County, Indiana west through southern Illinois to southwestern Missouri, northern and central Arkansas, and extreme eastern Oklahoma, south through central Tennessee to central and southern Alabama, and east to the mountains of eastern Tennessee, North Carolina, and extreme northern Georgia. However, this overall distribution does not really reflect the distribution of *C. lutea* since the species occurs disjunctly in numerous scattered localities (Figure 5). Wild yellow-woods are found in two quite different habitats: cliffs along river systems and openings in hardwood or hemlock forests of moist coves. Cove forests are most common in the southern Appalachian Mountains, and yellow-wood trees of these forests are tall with erect, flat crowns and trunks that fork fairly close to the ground. Toward the western and southern part of their range, yellow-wood trees occur primarily at the brink of cliffs, along ledges on cliffs, or sometimes toward the base of cliffs. Yellow-wood trees of the cliff habitat are small and have trunks that fork about half way up (much of the above information from Pittillo, 1963). Steyermark has noted that thousands of these rare trees have been destroyed by the construction of dams (Bull Shoals, Taneycomo, and Table Rock) along the White River and its tributaries of northern Arkansas and southwestern Missouri. Because of its rare occurrence, scattered distribution, and presence in areas subject to flooding by man-made dams, yellow-wood has been included in the Federal list of endangered plant species.

Yellow-wood is not for mass planting as a yard or street tree; it is, instead, for the discriminating gardener who will give it a prominent place among other rarities. Such a person will be rewarded. In winter, the beech-like bark and overall appearance of the tree is very attractive. In late spring, the tree is truly spectacular when in full bloom (heavy flowering occurs only every other year or so). The rounded shape of the crown, the rich green color and medium texture of the foliage, and the short trunk make the yellow-wood a nice tree during the summer. In autumn, the leaves turn a rich yellow. In short, the yellow-wood has something ornamental to offer at all seasons. The only unattractive period is when the fruits mature and, for a short time, hang on the trees in the fall. Perhaps someday plant breeders will develop a sterile form that does not set fruit and that might flower more regularly every year. Yellow-wood is hardy nearly throughout the eastern United States and southern Canada. It is not bothered by insect or fungal pests, is tolerant of most soil types, and can withstand moderate drought once it is established.

Yellow-wood is also for the patient gardener. First of all, it is rather difficult to find in nurseries, and, when available, it is usually

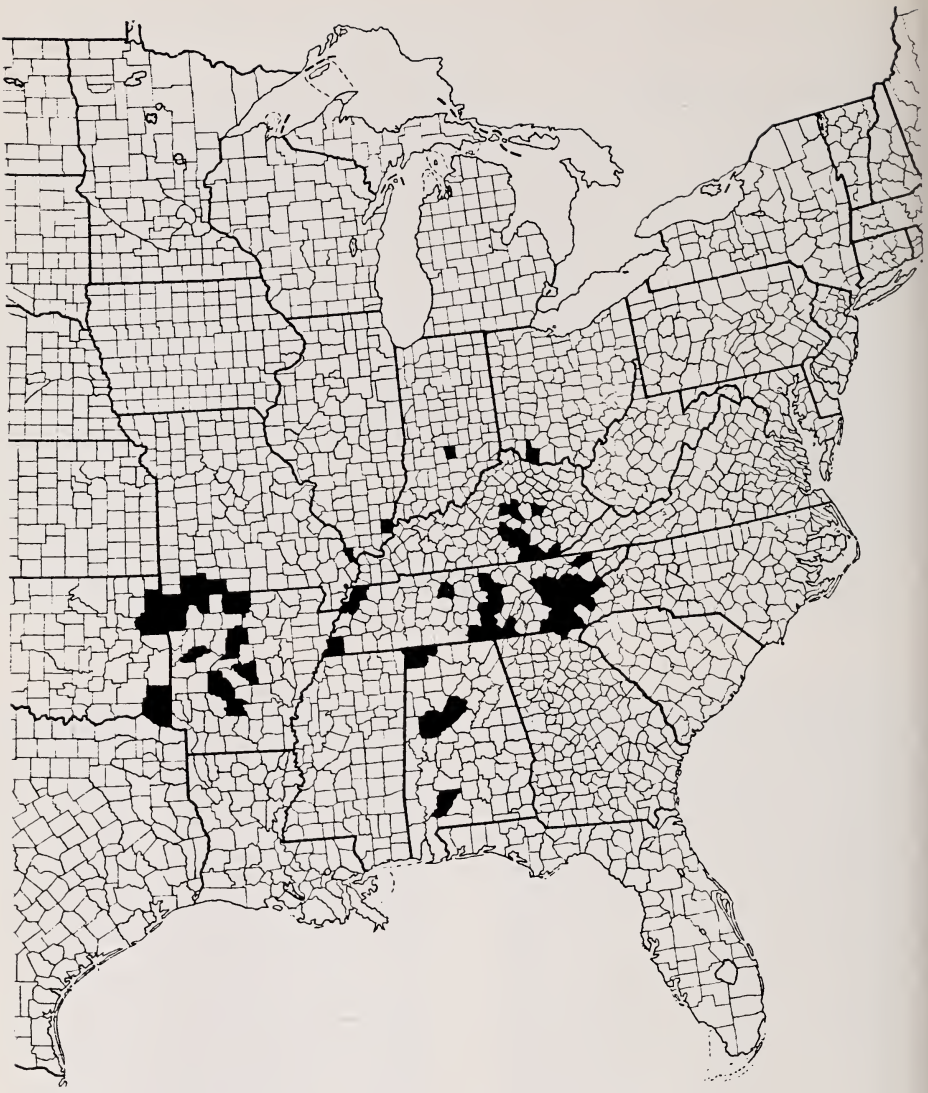

Fig. 5. Distribution map by county of Cladrastis lutea.

in limited quantities. It also is slow growing, taking ten to twenty years to flower for the first time, and it only flowers heavily every second or third year.

Although yellow-wood is not commonly cultivated, there are a number of fine specimens in Cambridge, Massachusetts, particularly in the vicinity of the Botanic Garden Apartments on Garden Street (former site of the Harvard Botanic Garden), in Mount Auburn Cemetery, and in the Tercentenary Theater of Harvard Yard between Memorial Church and Widener Library. The Arnold Arboretum's grove of yellow-woods is on the Tree Legume slope (Figures 1 and 4).

Yellow-wood may be propagated by root cuttings or by seed, which should be covered with hot water (190°F), allowed to set overnight, then stratified for three months at 40°F.

On the grounds of the Perkins School for the Blind in Watertown, Massachusetts is a pink-flowered yellow-wood. It is not at all clear where this tree originated, and there is no report of a pink-flowered form from the wild. This tree has been propagated by scions and distributed to the Arnold Arboretum and to the Brimfield Nurseries in Connecticut. A number of years ago, the Morton Arboretum, Lisle, Illinois, and the Arboretum of the Barnes Foundation, Merion, Pennsylvania obtained plants from the Brimfield Nurseries. The plant at the Morton Arboretum first flowered in 1970, while that at the Barnes Foundation first flowered in 1976. The plants at the Arnold Arboretum have not yet flowered. For more information on the pink-flowered yellow-wood, see Fogg (1976) and Wyman (1963).

While *Cladrastis lutea* is the only species of the genus native to the New World, there are four other species in eastern Asia. These are: *C. sinensis* Hemsl. of central and western China (Figure 6), *C. Wilsonii* Takeda of central China, and *C. platycarpa* (Maxim.) Makino and *C. shikohiana* Makino of Japan. All of these, except for the last species, are cultivated in Europe, but only *C. platycarpa* and *C. sinensis* are occasionally grown as botanical curiosities in this country. They are not as ornamental or as reliably hardy as our native *C. lutea*. *Cladrastis* is closely related to *Maackia*, and the two genera are sometimes united under the former name. *Maackia amurensis*, a native of Manchuria, is occasionally cultivated in the eastern United States for its July bloom.

KEY TO THE CULTIVATED YELLOW-WOODS

1. Legumes flattened but not winged; stipels absent. 2.
   2. Leaflets broadly elliptic or ovate with acuminate tips and tapering or slightly rounded bases; ovary glabrous; panicles mostly drooping. *C. lutea.*
   2. Leaflets oblong to oblanceolate with obtuse or acutish apices and rounded bases; ovary finely pubescent; panicles upright. *C. sinensis.*
1. Legumes flattened, winged all the way around; stipels present. *C. platycarpa.*

Fig. 6. A 60- x 10-foot specimen of Cladrastis sinensis *at base of Fei-Yüeh-ling in Ching Chi Hsien (5,000-foot altitude). Photo: E. H. Wilson, 1908.*

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Buckleya - The Oldest Cultivated Plant in the Arnold Arboretum

by Richard A. Howard

Although the Arnold Arboretum was legally established in 1872, the first plantings on the grounds did not occur for several years. It is of interest, therefore, that a plant collected in Tennessee by Asa Gray in 1843 was transplanted to Hemlock Hill in Jamaica Plain in 1946 and so represents the oldest documented cultivated plant in the Arnold Arboretum. Strangely, it is a semi-parasitic plant with an unusual history. It is not common in cultivation, has no well-known common name, and is to be recommended only for its oddity.

Buckleya distichophylla (Nutt.) Torrey was first seen by Thomas Nuttall in his travels along the French Broad River in East Tennessee in 1816. Nuttall, an English-American botanist and ornithologist, was to become the director of the Harvard Botanic Garden in Cambridge, Mass., in 1822, preceding the more famous Asa Gray. His discovery was described by him as *Borya distichophylla*, in his book, *The Genera of North American Plants*, in 1818. Unfortunately, he assigned it incorrectly to a genus in the Oleaceae, the olive family.

The plant was found again in the spring of 1843 by Samuel Bradford Buckley, a naturalist and plant collector for Prof. John Torrey of Columbia College. Torrey then correctly assessed the plant to represent a new genus of the sandal-wood family, Santalaceae, and named it *Buckleya* in honor of Mr. Buckley. Torrey recognized that the proper specific name was that published earlier by Nuttall, and made the transfer and new combination. Professors Torrey and Gray had published *A Flora of North America*, containing short descriptions of all the known indigenous and naturalized plants growing north of Mexico and were continuing a program of collecting unusual plants. Thus Gray sought out *Buckleya* in the fall of 1843 and returned with herbarium specimens and plants and fruits of the rare *Buckleya* for cultivation at the Harvard Botanic Garden, then under his direction. The introduction to cultivation of a living partially parasitic plant is unusual, yet it was successful. Herbarium specimens from this plant labelled "Hort. Cantab." or "Botanic Garden of Harvard University" are dated 1852, 1879, 1926 and 1930; the last two, by John George Jack for the Arnold Arboretum herbarium.

Charles Sargent was the director of the Botanic Garden of Harvard University in Cambridge from 1873 until 1879, and there he pre-

Buckleya distichophylla. *1. Flowering branch of the staminate plant, natural size. 2. Flowering branch of the pistillate plant, natural size. 3. Fruiting branch, natural size. 4. Staminate flower, enlarged. 5. Vertical section of a staminate flower, enlarged. 6. Pistillate flower, enlarged. 7. Vertical section of a pistillate flower, enlarged. 8. Vertical section of a seed, somewhat enlarged. 9. Embryo, much magnified. From* Garden and Forest, *3:237. 1890.*

pared plans and plants for the development of the Arnold Arboretum property in Jamaica Plain. One can assume that Sargent noted the lack of fertile fruits on the *Buckleya* in the botanical garden and attempted vegetative propagation. When this was unsuccessful, he sought additional plants from the wild and in 1888 he and W. M. Canby made a trip across the Smoky Mountains of Tennessee, including a "detour to the French Broad for the purpose of looking up *Buckleya*." He reported that he found plants in ripe fruit at Paint Rock and sent back several hundred seeds packed in damp soil as well as a number of small seedlings. All arrived at the Arboretum in

good order, and the seeds germinated "at once." These accessions were recorded in the numbered inventory of the Arnold Arboretum as "#3255," a plant collected by Sargent at Paint Rock, Tenn., Oct. 1888, and "3255-1 seeds" from the same area. Herbarium vouchers of fruiting specimens support the collection data. We have no record of the length of time the plants or seedlings obtained by Sargent were maintained in the living collections, for the existing records show only the undated annotation "dead or disposed of," representing a period when non-ornamental plants were removed from the living collections.

Sargent wrote of his search for this plant and of its introduction to cultivation in an article on "New or Little Known Plants" in *Garden and Forest* in 1890. A plate prepared by Charles Faxon was included and is reproduced here. *Buckleya*, as a native plant, was not included in any edition of *A Manual of Botany* as prepared by Asa Gray, although several of these editions included the state of Virginia, where the plant has been found. It was first mentioned in the 8th edition of *Gray's Manual of Botany* published by M. L. Fernald in 1950. Sargent mentioned the plant only briefly in a footnote in his *Silva of North America*. *Buckleya* is included in Rehder's *Manual of Cultivated Trees and Shrubs*, but supporting specimens for this record are only those of the Botanic Garden of Harvard University.

When the Botanic Garden in Cambridge was abandoned in favor of university-sponsored housing at the end of World War II, the shrub introduced by Asa Gray in 1843 and cared for by Charles Sargent in 1873 was transplanted to the grounds of the Arnold Arboretum in 1946. It continues to thrive in a natural stand of *Tsuga canadensis*, the Canada Hemlock.

Buckleya is a genus of dioecious shrubs, the male and female flowers occurring on different plants. The specimen Asa Gray collected is a female plant. *Buckleya* is known to be a semi-parasitic plant, that is, during part of its development it is dependent as a parasite on the attachment of its roots to those of other plants. The plant becomes a shrub, has green leaves, and does manufacture its own food. I have not been able to locate a 19th century reference to this parasitism, but herbarium specimens from the Biltmore Herbarium, collected in 1897, were made deliberately to show the haustorial connection with *Tsuga canadensis*. Since the natural range of *Buckleya distichophylla* is also that of the Carolina Hemlock, botanists speculate that *Tsuga caroliniana* might have been the original host plant. In the last decade, other botanists have reported an association of *Buckleya* with species of *Pinus*, and, in fact, as many as twenty-five different forbs, grasses and ferns as well as broad-leafed trees. Even today it is not clear at what stages of growth or for how long or to what degree *Buckleya* must be dependent on a host plant.

Sargent reported in 1890 the lack of success in attempts to propagate vegetatively the specimen of *Buckleya* in the Botanic Garden in

Cambridge. Since that time the Arnold Arboretum has acquired several seed lots of *Buckleya distichophylla* from native locations and from other plants in cultivation in the United States, and one infertile seed lot from the Forest Botanic Garden, Charlottenlund, Denmark. Mr. Fordham, longtime plant propagator for the Arnold Arboretum, has conducted many experiments with this species. In spite of Sargent's early report that seeds germinate "at once," Mr. Fordham has found that seeds failed to germinate when planted directly upon receipt. However, seeds given a cold treatment of 40 degrees for two or three months produced seedlings in over 50% of the cases. In 1962 a generous quantity of seeds and cuttings was received from Mr. Fred Lape from plants growing in the George Landis Arboretum in Esperance, New York. Mr. Lape wrote that the original plants in his collection came from seed collected by F. M. Crayton of Biltmore, North Carolina; they germinated well and are established in the Landis Arboretum as well as in an old woodlot. He reported that in one place "there is a spread of it the size of a small room," and that the large plants fruit heavily each year.

The cuttings received rooted poorly under mist propagation and developed roots only at the very base of the cutting. Other cuttings treated with Amchem 60–89 diluted to 5,000 ppm produced better roots. The seeds developed and the seedlings appeared to flourish without a *Tsuga* or any other host plant present in the container. Thirty-five of the vigorous seedlings were planted on Hemlock Hill in the Arboretum in 1963, but by the fall of 1964 all had died. Other seedlings planted near a hemlock in the nursery area persist to the present but have yet to flower and so are unsexed. Regrettably, these plants, even if staminate, are too far from the older pistillate plant for normal cross-pollination.

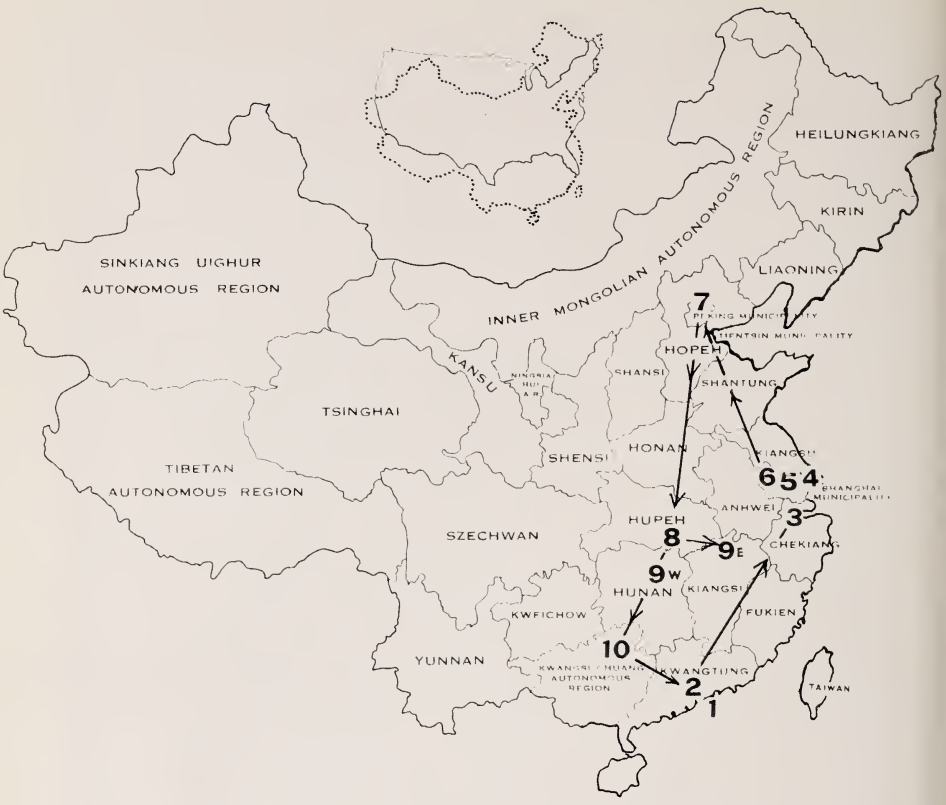
The fruits of the American *Buckleya distichophylla* are drupes resembling a small olive in size and shape. When mature they are a yellow-green in color and they turn a tan or light brown color on drying. The fruits may possess four narrow lanceolate bracts at the summit which are shorter than the fruit. These often fall early but if they persist are certainly of no aid in dispersal.

In 1846 the German botanical collectors Philip Siebold and Joseph Zuccarini described in their *Flora of Japan* a plant they called *Quadriala lanceolata*, literally referring in the name to the four large bracts found on the fruit. Friedrich Miquel, in 1870, recognized this plant to be of the same genus as *Buckleya distichophylla* of the United States, and published the combination. Thus *Buckleya* was recognized as one of the many plants occurring in the southeastern United States and in Japan and China. *Buckleya distichophylla* is known today from Tennessee, Virginia and North Carolina. *Buckleya lanceolata* (Sieb. & Zucc.) Miq. is known from Japan (Honshu) and China (Hona, Hupeh, Shensi, Szechwan) with a possible second Asiatic species, *B. graebneriana* Diels from Shensi in China. Two other

species from Asia have been referred to *B. lanceolata* in herbarium annotations made by Rehder.

In 1892 on a collecting trip to Japan, Charles Sargent found fruiting specimens of *Buckleya lanceolata* on the steep banks of the Kisogawa near Agematsu in Nagano prefecture of central Honshu in Japan. Upon his return Sargent wrote in *Garden and Forest* of the Japanese *Buckleya*: "Indeed it is so common in some parts of the country that the fruit, which is gathered when about two-thirds grown, having been subjected to some pickling or preserving process, is sold as a condiment, packed in small, neat wooden boxes. Nikko is the headquarters of the industry, and in late autumn the fruit of *Buckleya* is displayed in many of the shops which line the street leading through the straggling village up to the burial place of the founder of the dynasty of the Tokugawa Shoguns. To appreciate the flavor of *Buckleya*, the culture and refinement of the Japanese palate is essential." There is no record of the seeds Sargent described being grown at the Arnold Arboretum, but in 1905 John George Jack, Sargent's colleague, returned to the same area and obtained comparable fruiting herbarium specimens. It appears that both men might have attempted to introduce this species into cultivation. In 1964 the Arnold Arboretum received fruits of *Buckleya lanceolata* from the Kobe Municipal Arboretum in Kobe, Japan. After a cold treatment of 40 degrees for three months, several seeds germinated, but the seedlings could not be established. In 1902 the Japanese botanist, S. Kusano, in an article in the *Journal of the College of Science of the Imperial University of Tokyo*, noted that no information had been published on the host plants of *Buckleya* or for the abundant local species. He described the haustorial connections with species of *Cryptomeria*, *Abies*, and *Chamaecyparis* as well as nine genera of dicotyledonous trees and shrubs. Although he did not locate naturally occurring parasitism with *Pinus* or *Torreya*, he was able to establish such relationships experimentally.

Buckleya lacks a common name and never will be widely cultivated or useful as an ornamental plant. It is, however, a good example of a rare plant of limited distribution showing unusual phytogeographical relationships, representative of a small family, and worthy of a place in the educational collections of an arboretum. The oldest cultivated plant in the Arnold Arboretum also has an historical connection with several of America's distinguished botanists.



A map of modern China showing the possible route for a botanical tour with the places of interest marked by numbers: 1. Hongkong, 2. Canton, 3. Hanchow, 4. Shanghai, 5. Soochow, 6. Nanking, 7. Peking, 8. Wu-Han, 9E. Lu Shan Botanical Garden, 9W. Chang Sha, and 10. Kweilin. The insert shows the relative position of China in comparison with continental USA. Latitudewise, Peking is comparable to Gettysburg or Harrisburg, Pennsylvania (see text for explanation).

More About Tours of Botanists and Gardeners in China

by Shiu Ying Hu

Recently, an unusually large number of letters came to me from *Arnoldia* readers regarding my report on the "Tour of a Botanist in China" (35: 264-295. 1975). Two letters came from botanical friends in Peking, suggesting areas that need corrections; the other letters brought questions from botanists, horticulturists, dendrologists, landscape gardeners, etc., who are interested in going to the People's Republic of China to visit gardens and experimental stations. The purpose of this short article is to make necessary corrections in my former report, and to answer questions concerning the application for, and planning of, tours to China.

Corrections in Former Report

Regarding the Institute of Botany, Academia Sinica, referred to on page 276, the herbarium and library of the Institute have the collections of the former Fan Memorial Institute of Biology and those of the former Laboratory of Botany, National Academy of Peiping. On the next page, the *Flora Reipublicae Popularis Sinicae* was mentioned. The four volumes already published are: Pteridophyta: Ophioglossaceae — Oleandraceae, Rosaceae, Cyperaceae, and Scrophulariaceae (Part II). In the same paragraph, the enlarged Sixth National Convention was called by the Academia Sinica.

In order to prepare a report on my tour in China while my memory was fresh, I wrote the article in Hongkong, where the library facilities for botanical publications are inadequate. It was published before I returned to the Arnold Arboretum where the volumes of the flora mentioned above are available. The outline map used for illustrating the route of my trip is an old one used by people outside China. The contemporary term for "Manchuria" is the Northeast.

Answers to Inquiries

The questions that I have received from people interested in visiting China may be grouped into three categories: (1) application,

(2) places to visit, and (3) time and expenses. Readers are advised to refer to my former report, and to consider the following information as supplementary material.

Application: The first rule about tours to China is that the application for entry visas must be made with the official representatives of the People's Republic of China in the country of the applicants. In the United States of America, this is the Liaison Office, People's Republic of China, 2300 Connecticut Avenue, N.W., Washington, D. C. 20008. In other countries it may be the Chinese Embassy or Consulate.

The procedure for applying varies with the size of the visiting group. I have known people who went to China as individuals, or in small groups representing academic or research institutions, or as special interest tours of twenty to twenty-five. People who intend to make the trip as individuals can write to the consulate or the liaison office, or go in person, to ask for application forms. Those who plan to visit China in groups must have a leader who represents them in all communication with the liaison office. In writing to ask for the application forms, it will be helpful to state the nature of the group, the purpose of the visit, a list of the participants, and the places hoped to be included in the tour.

Programs of touring groups within China are prepared by the China Travel Service (CTS), which has various routes for different interest groups. However, it will help the CTS program makers when they know the intention of the group in visiting certain places, gardens, institutions, and people. In consultation with the botanical, horticultural, agricultural, and forestry organizations of the country, officers of CTS often try to include the specific places and people desired. In the tour in which I participated in the summer of 1975, I was the only person interested in botanical institutions and botanists in China. In my application, I listed over two dozen people and botanical gardens and institutions. Arrangements were made for me to see a large number of these.

Places to Visit: In 1963, I participated in a tour of the International Dendrological Society in the eastern United States of America. From this experience, I know the kind of gardens, natural areas, and botanical institutions European and American visitors like to see. My limited experience of living and traveling in China, and the information that my friends shared with me, enable me to tell approximately what places are available in China to satisfy the botanically minded or horticulturally inclined foreign visitors. For these reasons, I venture to offer a tentative itinerary for the reference of future tour planners.

The places suggested are marked by numbers on a map. Some of the places are mentioned in the letters of inquiry received. The insert of the map shows the longitudinally and latitudinally comparable positions of China and the USA and may help some tourists to plan the

kind of clothes to take along. There is no luggage problem within China, for all transportation and baggage are taken care of by the CTS.

1. Hongkong: Assuming that the tour lasts for a month and the group enters China via Hongkong, two or three days should be scheduled for seeing the vegetation and gardens there. The vegetation of Victoria Island has been under protection from fire for over one hundred years. The walk over the Peak will give a general idea of the species of Hongkong forests. In the New Territories, there is a beautiful 300-acre private garden — Kadoorie Farm — which is open to the public. It has a unique natural setting with streams, falls, colorful plantings, and spectacular view of the surrounding countryside with farms in the plains and a vegetation of fire-climax on the hillsides. If time allows, a stop should be made at the Tai-po-Kau Forestry Station of the Hongkong Government. Here one can see the results of afforestation under government management, the regeneration of a natural forest from a former village woods protected from cutting and fire, and the magnificent bamboo gardens planted in the 1930s when F. A. McClure was studying the bamboos of South China. Some of his species can be seen in this garden.

2. Canton: If the group is interested in the tropical gardens of China, two or three days should be allowed for Canton. In addition to the parks and gardens scheduled by CTS, requests should be made for visits to Kwangtung Botanical Garden, and the present Sunyatsen University located in the campus of former Lingnan University where F. A. McClure planted his Bamboo Garden. Permission may be obtained for visiting the following places of botanical and horticultural interest: Huang-pu (Whampao) where Peter Osbeck collected for Linnaeus in 1751 and Henry Fletcher Hance resided for a quarter of a century from 1860 onward; and Hua-ti (Fate-Flower Gardens) where William Kerr, the Botanical Collector of the Royal Botanic Gardens at Kew, obtained his specimens in the 1800s and where John Reeves got his plants for the Royal Horticultural Society, London in the 1810–20s.

3. Hangchow: Three or four days should be saved for this garden city of China. The CTS program covers many gardens by lakes and in hills (Fig. 1) and temple grounds. Special request must be made for visiting the Hangchow Botanical Garden, with particular emphasis on seeing the portion set aside as a natural reservation.

4. Shanghai: When our party was in Shanghai, we were shown schools and industry. After I returned to Canton, I was told of Miss S. K. Cheng's work in establishing the Shanghai Botanical Garden. Request should be made to see it.

5. Soochow: A minimum of three days should be allowed for this area. The program of CTS includes many gardens within the city, and the Tai Lake commune which takes the group into the countryside. The gardens in Soochow with the moon gates (Figure 2), and

Fig. 1. The Flower Creek Park of Hangchow including lakes and hills, with beautiful lawns, impressive deodar-cedar, graceful willows, elegant pavilions, and many interesting plants. (*See* Arnoldia 35: 268 *for details*).

the rock work are famous throughout China, and have been treated as a stereotype of Chinese gardens in many western books. They are old, and some of them can be traced to the Ming Dynasty or earlier. The Tiger Hill (Hu-ch'iu), which is a public park now, is the only one which has a natural setting of massive cliffs and steep gorges. It has a tea house and a slanting pagoda. The other gardens formerly were private and are small. By skillfull use of rocks and water, the designers were able to express nature in a reduced scale (Figures 3–4). Thus, in a small courtyard, one may feel the effect of hills, streams, cliffs and lakes, with plantings to fit with the ecological background.

6. Nanking: Two or three days should be scheduled for Nanking. The CTS program includes the Tomb area of Dr. Sunyatsen, the father of China as a republic. In the vicinity of the Tomb area the

Kiangsu Institute of Agricultural Sciences and the Kiangsu Botanical Institute and the Associated Botanical Garden, situated at the Ming Tomb, are two interesting places to visit. The vegetation of the Spirit Valley is better preserved than is that of the Tomb area, and the group may want to see a deciduous forest of eastern China there. Special requests must be made in advance for visiting the Nanking Technical Institute of Forest Products to see the result of Prof. P. C. Yeh's tree breeding, and the plantings of the medicinal plant gardens of the Nanking College of Traditional Chinese Medicine.

7. Peking: Four or five days should be set aside for Peking. There are many interesting places to see in this ancient city which is also the present capital. Botanically, Peking was the site where Alexander

Fig. 2. The moongate in a Soochow garden.

von Bunge collected in 1830–31. Many of our common ornamental garden trees and shrubs came from the Peking Hills, originally sent as seeds to the Arnold Arboretum and several European botanical gardens by Emil Bretschneider between 1866 and 1883. My time in Peking was too short to visit the hills. From the Palace ground I could see beautiful woods on the hills to the north, and also above the lake area of I Ho Yuan (Garden of Smiling Harmony, also known as the Summer Palace). My suggestion is that the tour leaders of botanical groups write to botanists in the Institutum Botanicum, Academia Sinica, 141 Hsi Chih Men Wai Ta Chie, Peking, for advice.

8–9. Central China. The following information I obtained from friends who visited Central China in the summer of 1973, and Kweilin in 1974. Hotel facilities are available for foreign visitors in Wu-Han (8) of Hupeh Province, and in Chang Sha (9w) in Hunan Province. People who have inquired about visits to Lu Shan Botanical Garden may like to know that Wu-Han is the nearest metropolis to Lu Shan. The name is an abbreviation of two adjacent cities, Wu Chang and Hankow (Han Kou). Botanists of the Hupeh Institute of Botany may answer questions about places of botanical interest in Wu-Han and about arrangements for visiting Lu Shan Botanical Garden.

Looking at a map of China, one may see that Wu-Han and Chang Sha are on a central artery of communication between Peking and Canton. It would be a very interesting trip if arrangements could be made for leaving Peking by train and stopping at Wu-Han for a few

days, then continuing the trip to Chang Sha by train. After visiting the hometown of Chairman Mao in Hunan, the group could proceed forward to Kweilin (Kwei Lin) in Kwangsi.

10. Kweilin: The natural beauty of Kweilin is well known in China. There is a saying that describes the superb scenery of the area: "The hills and waters of Kweilin is FIRST under heaven." There is a direct flight between Kweilin and Canton. A minimum of two days should be allowed for visiting this area.

Time and Expenses

The expenses of the trip depend primarily upon the time spent in China, and on personal likes and dislikes. Here I can only give my personal experience as a rough reference. I went to China with a Hongkong group (CTS Group 57). This designation was our identification and our address within China. It should be mentioned that when the name of an individual, the group number, and the city within China were given, all mail, telegrams, and long distance telephone calls were received.

In the summer of 1975, a Hongkong dollar was equivalent to US 20 cents; now its value is slightly higher. For the basic expenses of the tour, which was originally scheduled for July 12th (leaving Hongkong in early morning) to August 6th (leaving Canton at 8:20 A.M. and arriving Hongkong about noontime), each member paid in advance $4,000.00HK. This covered transportation, food, hotel (double room), and luggage. Later, our request for an extension of one more day in Peking was granted, and we each paid an additional charge of $100.00HK. The food was good and plentiful, the service excellent, the hotel rooms comfortable and with private baths, and the program full, including many entertainments in the evenings.

Drinks ranging from soft drink to beer, etc., are available in the dining rooms of the hotels at extra charge. In each hotel, there also is a shop for fruits, cigarettes, candy, and small gifts. In every city visited there was a Friendship Store that carried antiques as well as expensive modern articles. Such stores are open only to tourists.

Finally, it should be mentioned that hotel facilities for accommodating foreign visitors are limited in number and capacity. All the overseas Chinese holding passports of their naturalized countries are treated in China as foreign guests. On account of the large number of applications of these people who want to return to see relatives and friends, applicants often have to wait a long time for permission to travel in China. It pays to apply as early as possible and to be patient in waiting for the permit.

Acknowledgement

My deep appreciation is due to Miss C. H. Young and Mr. K. B. Liu for the photographs and for much help during my tour in China.

Fig. 3. Soochow garden rock work.

Ehretia thrysiflora. *Photo: P. Chvany.*

Woodland Ecology. Leon S. Minckler. Syracuse: Syracuse University Press. 229 pages, illustrated. $9.95.

Of all the potentially productive forest land in this country, 59 percent — 300 million acres — is under private, non-industrial ownership. In the eastern part of the country the figure is as high as 73 percent. This book addresses itself to these woodland owners, who number 4.5 million, emphasizing their responsibilities and privileges. Having worked for many years with the U.S. Forest Service at forest experimental stations and being now Adjunct Professor at SUNY College of Environmental Science and Forestry at Syracuse, the author knows his subject and his readership. He provides detailed information on the forces that bear on their woodlands and on techniques of channelling these forces towards economic and esthetic goals.

The book, which deals exclusively with the eastern U.S., begins with a concise description of forestry and silviculture. Then follows a systematic presentation of the seven types of eastern forests, the five classes of tree for timber production, the five methods of timber cutting and the seven principles of planting. An important chapter focuses on the relation of woodland management to wildlife and fish habitat.

Modern dilemmas are laid out on the table: "Wildlife and fish belong to the people, their harvest is controlled by the state, but the land where the wildlife lives and the shores of the streams are controlled by the landowner." Professor Minckler does not have the answer, but it is refreshing to see clear-sighted definitions of this and similar problems. He is a straight shooter. For example, pond management in his view is relatively simply stated: "The only way to have an attractive and useful pond is to have it properly constructed in the first place and then to prevent pollution."

The three appendices contain addresses of agencies and book references to which the woodland owner can turn for advice and actual help. It is stimulating to find a book on ecology that does not devote itself to crying havoc, but provides a well-written set of practical and philosophical guidelines for the future management of our forests.

Richard Warren

Ten-Minute Field Trips. Helen Ross Russell. Chicago: J. G. Ferguson Publishing Co. 172 pages, illustrated. $6.95 paperback.

The author has lifelong experience teaching children, and judging from the warm enthusiasm throughout her book, she must have been a marvelous inspiration to countless youngsters. Geared toward use by grade school teachers, the book presents a series of investigative "lessons" designed to teach the principles of nature study. As a source of ideas and information, it is equally valuable to parents, camp counselors and teachers of older children.

The institutional method makes full use of outdoor materials at hand, encouraging students to observe and investigate. A lesson on the dandelion brings together a multitude of disciplines. Counting individual flowerets and estimating reproductive possibilities teaches statistics and demography; etymology comes to the fore when one explains the deriva-

tion of the name from the French "dents-de-lion" and notices the supposed resemblance of the flowers to lion's teeth; in learning that the greens are edible, students are introduced to cultural and culinary practices of other people in other times.

Ten Minute Field Trips is a "learn and do" manual of exceptionally high quality. It deserves a position of prominence in classrooms throughout the country.

ELINORE B. TROWBRIDGE

Gardens Without Soil. Jack Kramer. New York: Charles Scribner's Sons. 127 pages, illustrated. $8.95.

The sprouted carrot top, sweet potato or avocado growing in a container of water has long adorned the kitchen window in many homes. This attractive, expensive, illustrated volume elaborates on the method of soilless culture, proposing that commercial or experimental methods of hydroponics can be used in the home or greenhouse. The point is stretched considerably with the suggestion that cauliflower, cabbage and squash can be so produced.

RICHARD A. HOWARD

Gardening With Perennials Month by Month. Joseph Hudak. New York: Quadrangle/The New York Times Book Co. 398 pages, illustrated. $12.50.

There are many books on "how," but too few that emphasize the "when." Mr. Hudak's new book is of value to the amateur gardener whose interest has been limited to the evanescent world of annuals, and it also will assist the professional in plant selection. Each chapter represents a month of the growing season and is preceded by a listing of the color values of various perennials selected for hardiness and growth characteristics. This information on time, color, and site should mitigate the concern of those who wish to plant perennials but are afraid that their mistakes will confront them for many seasons.

The descriptive material is clearly written, and the pictures are good. Although the selection of plants for a book of this size admittedly cannot be encyclopedic, it is eminently practical and satisfies the writer's criteria of endurance, growth habits, and flowering traits. A pleasant bonus is an alphabetically arranged descriptive list of hardy ferns and an addendum of plants for specific conditions such as perennials with a blooming period of eight weeks or more, perennials having the bonus of foliage effects with or after blooming, etc.

While the book's emphasis is on useful practicality, it is also enjoyable reading and can be recommended without reservation.

BARBARA O. EPSTEIN

New Plants From Old. Charles M. Evans. New York: Random House. 116 pages, illustrated. $3.95, paperback.

Cook books and manuals on growing house plants continue to proliferate. This simple, clear and instructive book on house plant pruning and propagation will certainly be of great assistance to the beginner. If it is read with care, the pleasures of plant propagation should be within the grasp of the rankest amateur.

An index of plants, listed both botanically and by their common names, and stating how they are best propagated, should be of much value to anyone who wishes to increase his house plant collection.

The format of the book is most attractive and the illustrations by Lauren Jarrett are both clear and charming.

From New Plants From Old.

Apples. Peter Wynne. New York: Hawthorne Books, Inc. 280 pages, illustrated. $12.50.

Apples are ancient, delicious, mythological, medicinal, sexually symbolic and beautiful in flower and fruit. A book on their multiple aspects and assets should be welcome; but unfortunately, this book is not adequate.

It attempts to cover the apple's history, culture and folklore, with a hundred pages of recipes as a final chapter. But the history is too brief, the culture written in an over-simplistic and patronizing style (surely we do not have to be told that "each blossom has five petals"), and the folklore is too long and too speculative. The recipes are mainly adapted from Victorian cook books, and consist of such standard fare as "Brown Betty" and apple pie.

Cora L. Warren

The Gardener's Catalogue. New York: William Morrow and Co. 320 pages, illustrated. $6.95.

This 14½" x 10½" paperback compendium, copiously illustrated with line drawings in the Victorian manner, is nothing more than a product of the scissors and the photocopier. In general, *The Gardener's Catalogue* consists of brief articles, lists and garden catalogue excerpts grouped under various topics. There are extensive lists of plant societies, plant sources, etc., some of them including England and Australia, so the editors obviously aspire to some sort of international market. Although there is a three-page index at the back, it is by no means complete.

For serious reference work, this book has many inaccuracies. A novice gardener will surely end up with horticultural indigestion. Because of its emphasis on the current popularity of nostalgia, however, it probably will sell well — only to grace many a white elephant table next year.

A Naturalist in Costa Rica. Alexander F. Skutch. Gainesville: University of Florida Press. 378 pages, illustrated. $12.50.

For more than thirty-five years, Alexander Skutch made a living in Costa Rica by providing herbarium specimens for institutions. He lived among the natives, acquiring a knowledge of their ornithology, horticulture, religion and economy. Despite the inexorable march of civilization and the resultant deforestation, vandalism and ecological upset, the author's joy in his surroundings is clearly felt. Skutch philosophizes on the myth that the tropical environment is one of easy bounty and explains how the "slash and burn" horticulture of the Mayans produced the present day nomadic population.

This work has the charm of the journals of Fairchild, Wilson and Teale. It is recommended to botanists travelling to Central America, to field naturalists in training, to armchair naturalists, and to those with a love of nature. I endorse it highly!

ELINORE B. TROWBRIDGE

Modern Potting Composts. A. C. Bunt. London: George Allen and Unwin Ltd. 277 pages, illustrated. £8.00.

The author introduces the need for changing to loamless potting compost by a comparison of the advantages and disadvantages of both loam and loamless based composts. An informative description of most available alternative compost components is followed by an analysis of the physical aspects of compost formulation, the principles of nutrition, and the procedures involved in compost preparation, fertilization and irrigation.

The manual, being written for the professional horticulturist, student and scientific hobbyist, includes many graphs, tables and figures which demonstrate the interactions between the potting compost, the plant material, and the cultural practices. The technical information, which is based on studies made in England, U.S.A. and several European countries, and the appendices, which contain important conversion tables and chemical constants, constitute a valuable reference manual for anyone intending to prepare composts for pot plants.

KENNETH D. SHAW

House Plants Indoors/Outdoors. San Francisco: Ortho Book Division, Chevron Chemical Co. 97 pages, illustrated. $3.98.

Over 350 color photographs make this an attractive volume to glance through at leisure, but pictures are definitely not its only attributes. A clear, well-written text explains everything from air layering Dracaenas to Zebrina propagation. Many excellent photographs illustrate such processes as repotting, pinching and watering. These visual aids should delight the beginning gardener, and in this case, a single clear photograph is worth a thousand words.

In addition to the usual sections on artificial lights, pests and diseases, bulbs and individual house plants, there is an interesting calendar that tells you what you should be doing with certain of your plants month by month. A source list gives some of the retail outlets for common and not-so-common house plants.

A book such as this certainly ought to recruit legions of indoor plant fanciers. In addition, with its reasonable cost and lucid presentation, it ought to find its way onto many experienced gardeners' shelves as well.

MARGO W. REYNOLDS

Zenobia pulverulenta. *Photo: P. Chvany.*

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Cover: Arisaema sikokianum. *Photo: R. Weaver.*

Wildflowers from East and West

by Richard E. Weaver, Jr.

Soon after plant explorers started bringing their specimens out of Japan, it became obvious to plant geographers and other botanists that the flora of that country was similar in many ways to the flora of eastern North America, and to a lesser extent, that of western North America as well. Asa Gray, Professor of Natural History at Harvard, was one of the first to draw the attention of the scientific community to this phenomenon, and he enumerated a list of about ninety genera of plants that occurred in two of these three areas and nowhere else on earth. As the rich flora of China became known, a similar relationship became obvious.

The reasons for the similarity of the flora of such widely separated geographic areas appears to have begun during the Tertiary era of geologic time (starting more or less seventy million years ago), when the climate of the earth was much different from today, and a rich forest of quite uniform composition covered much of the Northern Hemisphere. As climate changed and glaciation occurred, and as the continents became separated, much of this forest disappeared. Relicts remained primarily in eastern North America, Pacific North America, and eastern Asia, where the climate remained relatively stable. But the relict floras were then widely separated, and the plants of each geographic area evolved separately, resulting in similar but not identical floras. As a result, although certain genera may be common to two of the three areas, the representative species are often slightly different. In some cases, evolution proceeded a bit further, and the related plants are now classified in different genera. In other cases, a group became extinct in all but one of the areas.

Several years ago, I began to gather a collection of plants representative of this ancient Arcto-Tertiary forest, as it is commonly known. Following is an account of my experiences in growing some of these as well as descriptions of others I hope to grow someday. I have included plants from only a few selected families; all are herbaceous rather than woody. I shall call them wildflowers, a term that I find useful, although many other people consider it nebulous, misleading or unscientific.

First of all I offer a word of warning, or perhaps a tantalization. Many of the Asiatic plants are rare in cultivation in this country so they are difficult to obtain unless one is willing to import them from

abroad. A plant import permit may be obtained by writing for an application at the following address:

Permit Unit USDA
APHIS, PPQ
Room 638
Federal Building
Hyattsville, Md. 20782

At the end of this article I have included a list of nurseries, together with a few of their specialties, where I have been able to find some of these very fine plants.

Second, I offer a short general description of the growing conditions under which I have been working. Many people might consider wildflowers difficult to grow in anything other than a "woodsy" situation. My gardens have been in the City of Boston, in anything but such a setting. The first was in a small backyard, under the high shade of a White Ash and in the additional shade of the house for the entire afternoon. The whole yard had previously been a sandlot, so large amounts of organic matter were dug in. Most plants, particularly orchids, did well, although frequent watering was necessary, particularly in the early spring before the ash leafed out.

I recently moved my garden to a new location, most of it under the low shade of an old apple tree. The soil had previously supported a lawn, and it was quite heavy. I dug in a half-ton of sand and a good bit of organic matter. Again, the garden appears to be very successful, and it does not require a great deal of supplementary watering. A smaller part of my new garden is at the edge of a clump of hemlocks. The soil is light, humusy, and a bit dry. My only problem there has been the unidirectional sunlight, which causes the taller plants to "stretch."

The Arum Family (Araceae) is a large group of plants that has reached its greatest diversity in tropical regions. Many members of the family, for example *Philodendron*, *Dieffenbachia* and *Anthurium*, are among the most commonly grown foliage plants in our homes; others are familiar wildflowers in temperate regions.

Arisaema

Plants of the Arum Family are easy to recognize because of their distinctive type of inflorescence. The individual flowers are small and inconspicuous, but they are arranged on a fleshy spike technically termed a *spadix*. This structure is surrounded or even covered by a modified and commonly colorful leaf known as a *spathe*. The familiar Jack-in-the-pulpit (*Arisaema*) will serve as an illustrative example. The "jack" is the spadix and the "pulpit" is the spathe. This genus of about one hundred fifty species is most diversified in temperate and subtropical Asia, but a few species are native to eastern North America. Most authorities have considered our common Jack-

in-the-pulpit to be a single species, *Arisaema triphyllum*, variable in the shape, size, and color of the spathe. Now many botanists divide these plants into several species, restricting *A. triphyllum* to include only those plants with the spathe usually dark inside and not furrowed (without longitudinal ridges) on the outside, and with the hood horizontal rather than arched.

At any rate, these are curiously attractive plants with their distinctive inflorescences followed by clusters of brilliant scarlet berries and their bold, three-parted leaves. The large, fleshy tuber from which they grow has given rise to an alternative common name, Indian Turnip. Although the tuber is edible, it and all other parts of the plant contain crystals of calcium oxalate which, unless they are destroyed by repeated boilings, are excruciatingly irritating to the delicate linings of our digestive tract.

Closely related but quite different in appearance and much less common, the Green Dragon, *Arisaema dracontium*, is native to rich woods through much of the eastern United States and adjacent Canada. The leaves are rather curiously constructed, with five to fifteen leaflets of greatly varying size. The inflorescence is even more curious with its elongated spadix, the shorter flower-bearing portion tightly enclosed by the slender spathe.

Most of the forty or so Japanese species are generally similar to *Arisaema triphyllum*, although the spathes are variously colored, and the leaves often have more than three leaflets. Others, however, are bizarrely different. *Arisaema thunbergii* and its closest relatives are almost lurid in appearance. The spathe of *A. urashima*, one of these species I have grown, is large and dark reddish-purple streaked white, with a white blotch on the inside of the hood. The spadix is dark red-purple and greatly elongate, projecting as much as a foot from the spathe. The solitary leaf has a stout, purple-blotched stalk; the blade itself is divided into two parts, the axis of each strongly curved with the leaflets arranged only on the outer edge.

Arisaema sikokianum, on the other hand, is delicately beautiful. It is a small plant, less than a foot tall, and the inflorescence is well developed before the leaves expand. The spathe has a narrow, dark purple tube and an erect hood that is purple streaked with white. The spadix is pure white and the tip is expanded into a ball-shaped structure. The leaves have three to five leaflets, each one with a central, paler blotch.

None of the Asiatic species is generally available in this country. Many of the Japanese species should be hardy even here in New England with some protection in the winter, although I say this from their distribution in the wild rather than from experience since even the two species that I have been able to procure have yet to pass the test of a single winter outdoors. The Himalayan species, including some of the most wonderful of all, are probably tender.

Arisaema triphyllum is of the easiest culture and it may even become weedy. It is not fussy about soil, and it will flower well in moderate shade to nearly full sun. *Arisaema dracontium* prefers moister conditions with more shade, and so, I suspect, do the Asiatic species.

Symplocarpus* and *Lysichiton

The plants commonly called Skunk Cabbage are included in two different genera: *Symplocarpus*, with two or three species in eastern North America and eastern Asia, and *Lysichiton*, with two species in western North America and eastern Asia. They are similar plants with their thick spadices, colored spathes, and very large basal leaves appearing with or after the inflorescences. All are plants of moist to mucky soil, and they require the same for successful cultivation. *Symplocarpus foetidus* is the common Skunk Cabbage of the eastern United States. Its fleshy, reddish-purple spathes variously streaked and flecked with yellow-green usually poke out of the still frozen soil before the end of February in the Northeast. Their odor when crushed, and the large leaves that follow them by about a month, are the source of the plants' common name. The Japanese *S. renifolius* is so similar that it is often classified as a variety of our plant. The other Japanese species, *S. nipponicus*, differs in the shape of the leaves and in the fact that the leaves appear with the inflorescences. Neither of the Japanese plants is in cultivation to my knowledge.

The genus *Lysichiton* differs from *Symplocarpus* in the following obvious characters: The spadix of the former is longer and narrower, the spathe is not fleshy and is solid white or yellow, and the "skunky" odor is absent. *Lysichiton americanum* is native to the Pacific Northwest. It is truly a handsome plant with its lemon-yellow spathes that may stand nearly a foot tall. It is not an easy plant here in the Northeast, although a clump at the Will C. Curtis Garden in the Woods, Framingham, Mass., has flourished and flowered well for many years. The similar *L. camtschatcense*, with white spathes, is common in northeastern Asia. It should be hardy here in New England, and is available from a few wildflower nurseries.

The Lily Family contains some of the most wonderful of woodland plants, and it is almost impossible for me to imagine a wildflower garden without a generous representation from this group. A number of genera, for example *Uvularia*, the Bellworts or Merrybells, and *Medeola*, the Indian Cucumber Root, are endemic to the eastern United States; that is, they occur nowhere else. Others are represented also in the western United States and eastern Asia, and my discussion here centers on some of these.

Trillium

The largest and most diverse genus is *Trillium*, of course. If I were limited to growing one group of plants to the exclusion of all others,

Left: Trillium albidum. *Right*: Trillium discolor. *Photos: R. Weaver.*

I probably would choose this one. The Latin name of the genus is derived from the fact that the parts of the plants are in threes — three leaves, petals, sepals, and stigmas, and six stamens. It also indicates a major difference between Trilliums and most other members of the Lily Family: the fact that the sepals and petals are very different in color and structure rather than being similar, as in the true Lilies which appear to have six "petals."

Trilliums are easily divided into two groups of species, one in which the flowers are sessile (stalkless) and appear to arise directly from the junction of the leaves. In these species, the petals usually stand erect and the leaves are commonly mottled with brown and/or silvery-green. The other group contains species with flowers that are at the end of a distinct stalk and therefore are carried well above or below the leaves. The petals are spreading or even reflexed, and the leaves are never mottled.

The species of sessile Trilliums have been the source of confusion for botanists and gardeners alike. A recent study recognized twenty-two species, all of them American, and many very similar in general appearance. The most commonly grown species appear to be *Trillium sessile* and *T. cuneatum*, with maroon petals, and *T. luteum*, with yellow-green petals. I shall limit my discussion here to some of the less common species that I have grown.

Trillium discolor has a very limited distribution in the mountains of North and South Carolina. It is one of the most attractive of the sessile-flowered species native to the eastern United States, as well as

one of the most distinctive. Its most outstanding features are its pale yellow petals which are almost paddle-shaped; that is, with a broad, rounded upper portion gradually tapering to a narrow base. Also, the stamens are maroon in contrast to the greenish ones of other yellow-flowered species. This plant is not available commercially to my knowledge; I collected my plants in the wild.

Five species of sessile-flowered Trilliums are native to the western United States. The most distinctive, but the least showy, is *Trillium petiolatum*, with unmottled, almost round, long-stalked leaves that are held barely off the ground. The maroon flowers are almost hidden by the leaves. A very attractive species, on the other hand, and also one with unmottled leaves, *T. albidum* has flowers with white to white-chartreuse petals. It is often listed in catalogues as *T. chloropetalum*, another western species I have not grown. *Trillium angustipetalum*, as the species name implies, is distinctive because of its very narrow petals. They are bronzy-maroon in color and may be as long as 3 inches. I have received this species several times as either *T. chloropetalum* var. *rubrum* or *T. sessile* var. *californicum*. Since the identity of all these species is somewhat confused, it is very difficult to predict what will arrive when *"T. sessile"* is ordered from a nursery.

Trillium vaseyi. *Photo: R. Weaver.*

The species of *Trillium* with flowers on stalks are perhaps more familiar than the preceding to most gardeners. All but four species are American. The Himalayan *T. govanianum* is distinctive on account of its narrow petals that give the flower a spidery appearance. I have seen no reference to this species being cultivated in this country, although it is occasionally grown in Europe. The three Japanese species should all be hardy in New England. Perhaps the most unusual of these (but certainly not the showiest) is *T. smallii*, which normally has flowers without petals. Occasionally one, two or even three maroon petals are present, and then the flowers somewhat resemble those of our native *T. erectum*. The most attractive of the Japanese species is *T. kamschaticum*, a plant with broad leaves and erect flowers with white petals. It closely resembles the white-flowered form of *T. erectum* except that its ovary is cream-colored rather than maroon and there is no tinge of maroon at the base of the petals. The last species, *T. tschonoskii*, is similar in appearance to the preceding, except that the flowers are smaller, the petals barely exceeding the sepals in length. All three of the Japanese species are now available in this country, and *T. kamschaticum* has been for some time. This last is the only species that I have grown at present. It presents no difficulties in cultivation.

Most of the eastern American species are familiar to wildflower gardeners, so only a few will be discussed here. Those that hold their flowers below the leaves are confused taxonomically. *Trillium vaseyi* is the most distinctive of the four species which I shall recognize here, and is, in my opinion, one of the finest of the entire genus. It is the last species to bloom in my garden; the large, sweetly scented flowers with their broad, overlapping burgundy petals streaked with green on the outside usually open during the last week of May. They unfortunately are not held to their best advantage, being almost completely hidden from above by the broad leaves. This rather rare native of the Carolina mountains has been classified as a variety of *Trillium erectum*, but about the only characteristics it shares with that species are the color of the flowers and the shape of the leaves.

The delicate southeastern *Trillium catesbaei* (often listed as *T. stylosum*) just precedes *T. vaseyi* in bloom. It is often confused with the two following species, so its distinctive features will be stressed. The leaves are quite narrow so they do not completely obscure the flower from above. The petals are pink or white changing to pink with age, and they have a distinctly wavy margin; in addition they reflex backwards in a gentle arc. The anthers are bright yellow. *Trillium flexipes* and *T. cernuum* have been considered to be synonymous, but they appear quite distinct to me. Both are more northern in their distribution than *T. catesbaei*. Both also have broad leaves, somewhat like those of *T. erectum*, and their petals are white or pink. The flower of *T. flexipes* is generally held more or less horizontally rather than nodding and below the foliage. The petals

are not wavy-margined, and they reflex backwards in a gentle arc. The ovary and anthers are creamy-white. The flower of *T. cernuum* is completely obscured from above by the foliage. The petals are not wavy-margined and they reflex abruptly rather than gently. The anthers and ovary are maroon or pink. The last two species bloom about the same time and probably hybridize, so intermediates may occur.

Most Trilliums are of easy culture. Basically, deciduous shade and any good, light, slightly acid soil that is rich in organic matter are all that is required for successful cultivation of these wonderful plants.

Scoliopus

A close relative of *Trillium*, the genus *Scoliopus* is native to the moist lowland forests of Oregon and California. Two species, *S. bigelovii* and *S. hallii*, are known. These are odd plants with two basal leaves variously spotted with brown and one to three long-stalked, ill-scented flowers with erect, threadlike petals and much broader sepals that are basically dingy yellow with purple stripes. The flowers of *S. bigelovii*, or "Stinking Willie," are almost an inch across. This is the only species that is commercially available. I have tried it several times, and although it has bloomed, it has not persisted for more than three years. Many of the other plants from its native habitat are difficult to grow in our climate. They appear to be reasonably winter hardy, but the New England summers are too hot for them.

Disporum

The species of *Disporum* are native to eastern and western North America and eastern and southern Asia. For the most they are not showy plants, but their delicate flowers have a certain charm, and their attractive foliage remains in good condition throughout the growing season. The two species native to the eastern United States are similar in habit, both ultimately growing to about 18 inches tall. The Yellow or Common Mandarin (*D. lanuginosum*) ranges throughout the Appalachians from New York to Alabama. The nodding flowers with narrow, greenish-yellow segments are not conspicuous and are somewhat obscured by the foliage, but the bright orange berries are attractive in the fall. The closely related Spotted Mandarin (*D. maculatum*) occurs over the same range as the preceding species, but is a much rarer plant. It is also much more handsome, with its white or cream-colored flowers dusted with minute purple spots. The greenish-white berries are densely covered with short, wartlike protuberances. I consider this to be one of the finest plants in my garden but unfortunately I know of no nursery source where it may be obtained.

Above right: Disporum smithii. *Below:* Disporum maculatum. *Photos: R. Weaver.*

Of the three or four species native to the western United States, I have been successful with *Disporum smithii.* This is the smallest of the hardy species, seldom growing more than 8 inches tall in my garden. The greenish-white flowers are much more tubular in shape than are those of the preceding species, the segments spreading only at thir tips. The bright orange berries, almost half an inch in diameter, are showier than the flowers.

Of the Asiatic species, only the Japanese *Disporum sessile* is at all commonly cultivated in this country. The plant and even the flowers closely resemble our native Wild Oats (*Uvularia sessifolia*), of a different but related genus. The form most commonly grown is one with white variegation on the margin of the leaves. The giant of the hardy species, *D. flavum* may grow to be nearly 3 feet tall. This native of China is quite showy. The narrowly bell-shaped yellow flowers become apparent soon after the leaves of the developing shoot begin to unfold, but they become fully exposed only when the plant reaches its mature height.

All of the species of *Disporum* mentioned above have been hardy and vigorous for a number of years in my garden. They thrive under the same conditions described above for Trilliums. I have tried growing several species from seed without success, probably because the seed was not fresh, but seedlings of *D. lanuginosum* and *D. smithii* have appeared in my garden.

Stenanthium

The genus *Stenanthium* is one unfamiliar to many wildflower gardeners, but it includes one of the finest herbaceous plants native to the eastern United States. *Stenanthium gramineum* var. *robustum* (sometimes considered a distinct species, *S. robustum*), Featherbells or Featherfleece, blooms in August, a valuable attribute in itself. The hundreds of small, white, narrowly bell-shaped flowers are grouped into a loose panicle as much as 2 feet tall. The inflorescence towers above the long narrow leaves on a slender stalk, the tip often being as much as 5 feet above the ground. The flowers turn green as the fruits are developing, and they remain ornamental until frost. The typical *S. gramineum* is a similar but much smaller and less showy plant, but is still well worth cultivating.

Both plants are distributed throughout the southern Appalachians, but var. *robustum* ranges into the Midwest and as far north as Pennsylvania. They grow best in nearly full sun as long as the soil is not too dry. In more heavily shaded situations, the inflorescences tend to be weak and floppy.

The western species, *Stenanthium occidentale*, is a plant of streamsides and boggy places in the mountains from British Columbia to Montana and northern California. It is quite different in appearance from our eastern species, being very slender and seldom more than

Disporum flavum. *Photo: R. Weaver.*

a foot tall. The inflorescence is a simple raceme and the flowers are bronzy-green, giving rise to the common name "Bronze Bells." I have a few seedlings of this species and they have proved to be hardy. They are less than vigorous, but I have them in a fairly dry situation. The remaining species, *S. sachalinense*, is a poorly known plant native to the island of Sakhalin, north of Japan. It is not in cultivation.

The American species are easily grown from seed, a two-month period of cold stratification being necessary for germination.

Clintonia

The six species of *Clintonia* are equally divided between eastern North America, western North America, and Asia. The Bluebead Lily, *C. borealis*, is one of the most characteristic plants of the coniferous forests of the northern United States and southern Canada east of the Great Plains. It is an attractive plant with its two or three broad, glossy basal leaves and loose umbels of greenish-yellow flowers followed by clusters of berries that are about as blue as anything in the plant world. Cultivation is easy as long as a cool, acid soil and shade are provided. My clump has been vigorous for a number of years, but flowering has been unreliable. Plants of all Clintonias should be moved soon after flowering because, like some other members of the Lily Family, the shoots of the present season are annual but produce offsets which will in turn give rise to next season's plants.

The Speckled Wood Lily, *Clintonia umbellulata*, is a common plant in the rich deciduous forests of the southern Appalachians. The

Clintonia umbellulata. *Photo: R. Weaver.*

leaves are similar to those of the preceding species, but the flowers are held in much tighter umbels, and the segments are white, tipped or dusted with purple. The berries, which are seldom formed in my garden, are black or blue-black. This is a most satisfactory plant in cultivation, flowering well and soon producing clumps of attractive foliage under cultural conditions that are suitable for Trilliums.

The species of western North America are a bit more difficult to cultivate here in the East, again because they are plants of the moist forests of the Pacific Coast and intolerant of our hot summers. The Queen Cup, *Clintonia uniflora*, differs from other members of its genus in that its large, white, upfacing flowers are borne singly rather than in clusters. This is a very beautiful plant, often forming large clumps in the wild. Unfortunately, I have not had it persist for more than a season although I have tried it several times in several different situations in my garden. *Clintonia uniflora* does grow in the mountains of western Montana, and I suspect that material from there might be easier to cultivate; most of the wonderful coniferous trees from the Pacific Northwest have proved satisfactory here at the Arnold Arboretum only if they were collected in this eastern, more continental outlier of their ranges.

Perhaps the most beautiful species in the genus, *Clintonia andrewsiana* is native to the Redwood forests of California. The plant is more like our eastern species than the preceding, but the flowers are red. A clump persisted in my garden for several years, but it never flowered.

The Asiatic species are closely related and have been considered synonymous. *Clintonia alpina* is native to the Himalayas, and *C. udensis* is widespread through Japan, China and eastern Siberia. They are evidently quite attractive plants, although I have never seen them in bloom. The flowers are white, about an inch across, and are arranged in racemes rather than umbels. The plants are somewhat taller than our species, sometimes standing nearly 18 inches tall in flower. I have not seen reference to either species being cultivated in this country, although *C. udensis* is occasionally grown in England. This species should be hardy in New England, and as a plant of coniferous forests should require about the same cultural conditions as *C. borealis*.

Helonias and ***Heloniopsis***

One of the rarer members of the Lily Family native to the United States and the only species of its genus, *Helonias bullata*, the Swamp Pink, occurs in scattered localities in swamps and bogs from New York to Georgia. It is perhaps most abundant in the Pine Barrens of New Jersey. It is an intriguing plant to me, and one I have always wanted to grow, but I have not yet found a source. The long, narrow basal leaves are numerous and evergreen, and they lie flat on the ground after flowering. From the rosette arises a stout, hollow stalk 10 to 18 inches tall, at the tip of which is borne a short, dense raceme of flowers with a most appealing combination of colors — the sepals and petals are pink and the protruding anthers are blue. The plant apparently requires abundant moisture for successful cultivation, and sun or partial shade. Once established it can be quite persistent, as evidenced by the fine colony at the Will C. Curtis Garden in the Woods, headquarters of the New England Wildflower Society.

A closely related genus, *Heloniopsis*, includes a few species of beautiful plants native to Japan, Korea and Formosa. I have grown *H. breviscapa* (or *H. orientalis* var. *breviscapa*) for several years, and it appears completely hardy although it flowered for the first time this past spring. Besides being attractive, the flowers of this Japanese native appear in early April. If my plant is typical, the stalk of the inflorescence is very short at flowering time, and the flowers seem to be nestled among the flat rosette of evergreen basal leaves. The stalk elongates gradually, and by the time the flowers wither, it may be 6 inches tall. The flowers themselves are bell-shaped but with narrow segments that are pink, beautifully accentuating the blue-lavender stamens and pistil. I have had good luck with my plant in light, humusy soil at the edge of a grove of hemlocks.

A number of our native orchids, including *Pogonia, Tipularia, Galearis* (*Orchis spectabilis*) and *Arethusa*, have close counterparts in the Japanese flora. I shall limit my discussion here, however, to those species I have had experience in growing.

Liparis

Liparis is a large cosmopolitan genus of about two hundred fifty species of terrestrial and epiphytic herbs. One of these, *Liparis liliifolia*, the Lily-leaved Twayblade, is a familiar, if somewhat uncommon, orchid of the deciduous forests of the eastern United States. It is one of our few native orchids in which the base of the stem is swollen and modified as a pseudobulb, the usual condition in the tropical, epiphytic orchids so commonly grown as greenhouse plants. Although not showy, this is a charming plant with its odd flowers dominated by the flat, broad, almost translucent brown-purple lip. It is also an orchid of easy culture, now having flourished and bloomed reliably for several years in my garden in a light, rich soil and deciduous shade.

The nearly identical *Liparis makinoana* is widely distributed in Japan. This species is more robust than our native one, with longer spikes and larger flowers. It is difficult to obtain in this country, and I have only recently found a Japanese source for the plant. It should be hardy, and should require about the same cultural conditions as our native species.

Cypripedium

The genus *Cypripedium*, the Ladyslippers, contains some of the showiest orchids native to the North Temperate Zone. As in all orchids, the third or central petal is expanded into a structure termed a "lip." Unlike other orchids, the lip in the Ladyslipper flower is inflated and pouchlike, sometimes resembling a slipper — hence the common name of the genus. The typically hairy leaves of these plants are characterized by having several large and conspicuous longitudinal veins, and they appear as if they had been folded. This character is enough to separate them at a glance from the greenhouse Ladyslippers which are now classified in the genus *Paphiopedilum* and are native to tropical Asia.

Between thirty and forty species (depending on whose taxonomy you follow) are native across much of North America and Eurasia, with a concentration in Eastern Asia. The familiar Yellow Ladyslipper (*Cypripedium calceolus*), represented by several varieties, is the most widely distributed species. The var. *calceolus* is native throughout North Temperate Eurasia, although it is now rare or extinct in many parts of its original range. The large-flowered var. *pubescens*, with yellow-green lateral petals, and the smaller flowered var. *parviflorum*, with brown-purple petals, originally occurred in forest areas through much of the United States and Canada, although the latter plant is more northern in distribution. These last two varieties intergrade to some extent, both in the size of the flowers and the color of the petals.

The exotic but delicate beauty of the Yellow Ladyslippers, plus their ease of culture, has made these plants popular subjects for the wild-

Cypripedium calceolus *var.* pubescens. *Photo: R. Weaver.*

Cypripedium japonicum. *Photo: R. Weaver.*

flower garden. They are perhaps the easiest native orchids to cultivate, and they will succeed and even increase in ordinary garden soil as long as there is not vigorous root competition from other herbaceous plants. It should be noted that they will need to be watered frequently during the springtime if grown in sandy soil, and that a high deciduous shade is ideal. All of the varieties reportedly grow best in neutral or slightly alkaline soil, but I have had excellent luck in our acidic New England soil, even though the plants seem to be more vigorous now that I have added a few pieces of mortar rubble about their roots.

The other eastern American species of Cypripedium often present some difficulties for successful cultivation. The Pink Ladyslipper or Moccasin Flower (*Cypripedium acaule*) is notoriously difficult, and the various tips for successful cultivation have not worked for me. The delightful *C. candidum*, the Small White Ladyslipper, is a rare plant and should not be attempted by anyone who has not had success with other species. It is reportedly easy to grow, requiring a good bit of sun. I have had only one plant of this species. It has persisted for several years, but has yet to flower. The Showy Ladyslipper, *C. reginae*, certainly among the finest of the genus, also is a light lover. It needs some moisture to do well, but soggy conditions invariably cause it to rot.

The diminutive Ram's Head Ladyslipper (*Cypripedium arietinum*) is unique in its purple-veined, oddly shaped pouch. In cultivation it appears particularly susceptible to rot, so I would recommend a light soil to which peat has been added and a site with rather dense shade, such as under hemlocks or Rhododendrons. One plant at least has flowered two out of three years under such conditions in my garden. This species is native in scattered localities in the northeastern and north-central United States and adjacent Canada, and also in eastern China. The Chinese plants differ from ours in a few minor characteristics, and have been classified as a separate species, *C. plectrochilon*. As far as I can determine, these plants have never been brought into cultivation.

A few species are native to the western United States, but I shall mention only one here. *Cypripedium montanum*, the Mountain Ladyslipper, is native to the mountains from southern Alaska to central California and Wyoming. This to me is the most beautiful of the American species. The brown-purple lateral petals are widely spreading and the slender pouch appears to be made of fine white porcelain. Otherwise it somewhat resembles *C. calceolus* var. *parviflorum*, except that a single plant may carry as many as three of the exquisite flowers. Unfortunately this species is not particularly easy to cultivate. It apparently grows best with cool soil about its roots, so planting in rather dense shade would be best. I have had a plant flower for two years under a Rhododendron, but it eventually died out.

Only a few of the wonderful Asiatic species of *Cypripedium* are cultivated in this country, although many would be hardy even in New England; none are available commercially to my knowledge. The widespread Eurasian *C. macranthum* and its varieties, and the Himalayan *C. cordigerum* are being grown, however, by a few local enthusiasts, but I have been unable to obtain healthy plants. Perhaps more dramatic than beautiful, the Japanese *C. japonicum* is unusual in the genus in having a pair of broad, fanlike leaves at the top of a short stem. The striking flower, arising from between the leaves, somewhat resembles that of our Pink Ladyslipper. The color is basically yellow-green with red spots, except for the pouch which is white with red streaks and spots. Unlike our native species, *C. japonicum* grows from a slender creeping rhizome. I received a small plant of this species from England three years ago. It has prospered, and this year, to my delight, it flowered. As soon as the shoot appeared, I started squeezing it gently, as I do all my Ladyslippers and Trilliums, hoping to find a flower bud. I could hardly contain my anticipation from the first day I could be certain that the hard lump within the folded leaves would actually produce a flower. The plant has been under Mountain Laurel (*Kalmia latifolia*) and a year ago was moved under a group of hemlocks where the soil is light and humusy and quite acidic. I have watered it occasionally through the summers, and have always protected it with about 6 inches of pine needles in the winter.

Goodyera

The forty or so species of *Goodyera* are widely distributed in the Northern Hemisphere. They are low, evergreen, rhizomatous herbs with mostly basal leaves that are various shades of green with paler green mottling or venation. The flowers of most species are small and whitish and are borne in dense spikes well above the foliage. The mottled leaves and the habit of the plants have given rise to the common name "Rattlesnake Plantain." Four species are native to North America. One of these, *G. pubescens*, the Downy Rattlesnake Plantain, is one of the commonest orchids in the eastern United States. Another, *G. repens*, has a circumboreal distribution; that is, it ranges around the world at northern latitudes.

Of the several Japanese species, I have grown *Goodyera macrantha*. This native of eastern and southern Japan is very different in appearance from our native species. The plants have a short, somewhat creeping stem and the leaves are a deep, velvety-green with a pale green central stripe. The inflorescence is very short-stalked and the two to four flowers are almost an inch long. My plants is growing in dryish soil under hemlocks and it survived the past winter with a generous mulch of pine needles.

The remaining orchids to be discussed here are Asiatic species that do not have close relatives in the United States. All, however,

are worthwhile if somewhat challenging subjects for the wildflower garden.

Bletilla

The first, *Bletilla striata*, often listed as the "Hardy Chinese Orchid," is readily available from commercial sources in this country. This native of China and Japan is an exceptionally attractive plant, both in flower and afterwards. The plants may attain a height of 18 inches in flower, with two or three bold, strongly ribbed leaves that may be a foot long and 3 inches broad. The 1½- to 2-inch, rose-purple flowers are borne in loose spikes of three to seven and individually resemble a *Cattleya*, the commonest corsage orchid, in general form.

Bletilla is probably not hardy without protection in the Boston area. However, I have had several plants outdoors for three years, and although they have increased threefold, they flowered for the first time this season, every shoot having produced an inflorescence. The plants are situated directly by the house with a southern exposure, in heavy and not particularly rich soil, and partially shaded by a pear tree. I have mulched them with about 6 inches of pine needles during the winter.

Cymbidium

The genus *Cymbidium* contains about forty species of terrestrial and epiphytic herbs native primarily in the Old World tropics. The numerous commercial hybrids are among the most spectacular of orchids. While perusing Ohwi's *Flora of Japan*, I discovered that one species, *C. goeringii*, is native in that country as far north as 42°, about the latitude of Boston, so I suspected that it might be hardy here. I obtained a plant from Japan during the summer of 1976 and planted it in my garden at the base of a rock in shallow soil over a 3-inch layer of pebbles. During this past winter I protected it with about 8 inches of pine needles, and to my delight when I uncovered it this spring I found that only the end portions of the old leaves had sustained any damage at all; the new growth was firm and green. It is too early to tell whether or not the plant will flower, but to have had it survive even one winter outdoors is exciting indeed.

Cymbidium goeringii, is admittedly one of the least spectacular of its genus, but it and its numerous forms and cultivars are extensively cultivated by the Japanese. The plant itself resembles most of the other Cymbidiums, with short, ovoid pseudobulbs and long, narrow, evergreen leaves. Unlike most of the other species, the flower, bascially green and white, and 2 to 3 inches broad, is borne singly rather than in a long, multiflowered spike.

Calanthe

Calanthe is another genus of greenhouse orchids with hardy or semi-hardy species. Three of these, *C. nipponica*, *C. discolor* and *C.*

torifera, are native to the Japanese island of Hokkaido at latitudes comparable to that of Boston. I have tried *C. discolor*, a deciduous species. A plant survived last winter outdoors with a mulch of pine needles, but at the time of writing (20 May) it had only begun to make growth, so further observations are not possible at this time.

The Barberry Family (Berberidaceae) includes a number of herbaceous genera, some of which have been classified in separate smaller families (e.g., the Mayapples in the Podophyllaceae), but they all will be discussed together here.

Podophyllum

The Mayapples are perhaps the best known of this group, and indeed *Podophyllum peltatum* is one of the common wildflowers in deciduous woods through much of the eastern United States. It is as typical a plant of the virgin forests in the Great Smoky Mountains as it is of the small woodlots so common in the mid-Atlantic States. The large, umbrella-like, deeply lobed leaves, two per plant on flowering individuals, hide the solitary, large white flower and the fleshy yellow fruit that follows it. Although the creeping rhizomes are seriously poisonous if eaten, the fruit is edible when ripe.

The remaining species in the genus, *Podophyllum emodi*, is a plant of the Himalayas (var. *emodi*) and the mountains of western China (var. *chinense*). This is an even more attractive plant than our native one, and certainly deserves to be more widely cultivated than it is at present. The most obvious difference between *P. emodi* and *P. peltatum* is that the flowers of the former are often pinkish and somewhat cup-shaped, held above the leaves as they open but overtopped as they fade. The plants of the Asiatic species also are more robust and not rhizomatous; the leaves have sharp-pointed rather than rounded teeth and lobes, and the berry turns bright red when mature. The var. *chinense* differs from typical *P. emodi* in having rose-colored flowers and more deeply lobed leaves. Both varieties should be hardy here in New England, but I have only grown var. *emodi*.

A closely related genus, *Dryosma*, includes a few species that are often listed under *Podophyllum*. These natives of Formosa and southern China have red or purple flowers in clusters, and appear to be truly wonderful plants. They probably are quite tender, unfortunately.

Both species of *Podophyllum* are easily cultivated, and *P. peltatum* may even become invasive. Both prefer high or partial shade, but *P. emodi* has flowered well for me at the edge of a clump of hemlocks. Seeds of the Asiatic species are available from a number of sources in England. They germinate well even if not particularly fresh, requiring about two months of cold stratification. The plants should bloom in their fourth season.

Plates reprinted with permission from Curtis's Botanical Magazine *are, clockwise from top left:* Podophyllum emodi *var.* chinense (*Vol. 146, 1920*); Cypripedium montanum (*Vol. 119, 1893*); Arisaema sikokianum (*Vol. 162, 1940*); Jeffersonia dubia (*Vol. 164, 1948*). [*These and plates following are* © *by The Royal Horticultural Society, London.*]

Diphylleia

Closely related to the former and similar in general appearance, *Diphylleia* or Umbrella Leaf, includes three species, none of which is common in cultivation. *Diphylleia cymosa* is native to rich, moist forests in the southern Appalachians. It is a tall but not coarse plant, robust individuals standing nearly 3 feet high. Like *Podophyllum*, each flowering shoot bears two broad, coarsely lobed leaves. The flowers themselves are white, about an inch across, and are borne in small clusters that are held above the leaves. They are followed by clusters of small, bright blue berries.

The similar *Diphylleia grayi* is native to alpine and subalpine areas of northern Japan. The major difference between the two species is that the leaves of the Japanese plant are only shallowly lobed. The Chinese *D. sinensis* is poorly known. Only our native species is available in this country, and then from only a few collectors and growers of native plants. It is a valuable accent plant in the wildflower garden due to its height and its bold foliage. Although it usually grows in moist areas in the wild, abundant moisture is not necessary for its successful cultivation. My plant of *D. grayi* is a recent acquisition, so I can report little of its cultural requirements. Being from high elevations, however, suggests that it should be kept as cool as possible.

Jeffersonia

The Twinleaf (*Jeffersonia diphylla*) is an attractive spring-flowering plant native to rich woods in the eastern and midwestern United States. In general appearance it is similar to the Bloodroot (*Sanguinaria canadensis*), a much more familiar plant of a different family. The solitary flowers, about an inch across with eight white petals, are unfortunately short-lived. The long-stalked leaves appear with the flowers and their curious shape has given rise to the plant's common name; they are split down the middle into two broad, nearly identical segments, recalling the wings of a butterfly.

The only other member of the genus, *Jeffersonia dubia* (sometimes classified in a distinct genus, *Plagiorhegma*) is native to a small area in northeastern Asia, on the border of China and the U.S.S.R. It is more attractive than our species, since the flowers are a pale blue-lavender (very pale in some clones). Of the Asiatic plants discussed here it is one of the commonest to be cultivated in this country. Both species are perfectly hardy in New England, and they are easy to grow under deciduous shade. *Jeffersonia dubia* often occurs naturally on soils derived from limestone, but it appears perfectly vigorous in acid soils.

Epimedium and ***Vancouveria***

The genera *Epimedium*, from eastern Asia, southern Europe and North Africa, and *Vancouveria*, from western North America, are closely related and have been combined by some botanists. Unlike

Left: Bletilla striata. *Right*: Diphylleia cymosa. *Photos: R. Weaver.*

most of the plants under consideration, they have no counterpart in the flora of eastern North America. Both groups are exceptionally ornamental, with decorative foliage and curious but attractive and often brightly colored flowers. Most species in both genera are clump-forming or rhizomatous, and therefore are often used as groundcovers.

The flowers are composed of two series of sepals, the outer ones inconspicuous or deciduous soon after the flowers open, and the inner ones colored and resembling petals. The petals themselves are inconspicuous in some species, but in others are prolonged into tubular or club-shaped spurs. Although similar in general appearance, the two genera are easily distinguishable upon close inspection of the flowers. In *Vancouveria* the flower parts are in sixes, and the sepals and petals reflex, exposing the stamens and pistils; in *Epimedium*, the flower parts are in fours, and the sepals and petals do not reflex, mostly hiding the stamens and pistils. Inside-out-flower, the common name of *Vancouveria*, is a bit clumsy, and Barrenwort is an unattractive name for so singularly attractive a group of plants as *Epimedium*, so I prefer to call these genera by their Latin names.

Epimedium pinnatum *var.* colchicum. *Photo: R. Weaver.*

The three species of *Vancouveria* are native to the moist forests of the Pacific Coast, and all are hardy in New England. The most widely distributed and only commonly cultivated species, *V. hexandra*, is a vigorous plant spreading by rhizomes. The inflorescences of six to forty-five white flowers stand over a foot tall, well above the leaves. The deciduous, twice-compound leaves are divided into three nearly equal parts, each one with three to nine, three-lobed leaflets. The remaining species are not nearly so vigorous in our climate. Both have leathery leaves that are evergreen in their native habitat, although they are barely so here. *Vancouveria chrysantha* is restricted in distribution to the Siskiyou Mountains of southwestern Oregon, and, as the specific name implies, has yellow flowers. They have been sparsely produced in my garden. *Vancouveria planipetala* is a plant of the redwood forests of California. It has tiny white flowers held in a rather tall panicle, and they appear in late June, several weeks after those of the other species. All of the species are easy to cultivate in light, humusy soil. They bloom well in rather dense, evergreen shade, although *V. hexandra* at least will tolerate a good bit of sunlight.

Epimedium contains about twenty-five species centered in Japan and China, with a few in Europe and North Africa. Several of these, with their various hybrids and selected forms, are commonly cultivated and commercially available. The following discussion will not be an exhaustive one. Only a few selected species, representing various types within the genus, are included.

Epimediums are spring-flowering, and the commonly cultivated species are essentially past bloom by the end of May. But their foliage is attractive through the growing season, and a few species are partially evergreen. *Epimedium diphyllum* is the smallest species in general cultivation and also about the last to flower. The flowers are less than a half-inch across, pure white, and spurless, and they are held barely above the leaves. The leaves themselves are composed of only two leaflets, and these are nearly smooth along the margins and very lopsided at the base. This Japanese native seldom grows more than 6 inches tall, and it is densely clump-forming. *E.* × *youngianum*, the hybrid between this species and *E. grandiflorum*, is similar in general aspect, but it has larger flowers with short spurs, more leaflets per leaf, and is somewhat taller. It is more common in cultivation than *E. diphyllum*. *Epimedium grandiflorum*, a native of Japan, Korea and northeastern China, is one of the showiest species in cultivation. The flowers are usually more than an inch across, the size due largely to the elongated spurs that project conspicuously from beneath the sepals, giving the flowers a spidery appearance. The color varies from white to pale lavender, deep rose, or pale yellow in the various forms. The leaves are two to three times compound, with small, conspicuously toothed leaflets. The plants are usually less than 10 inches tall and are loosely clump-forming.

The North African *Epimedium perralderianum* and the closely related *E. pinnatum*, from the area between the Black and Caspian Seas, form loose colonies by long, fast-spreading rhizomes; they are perhaps the best species to use as groundcovers. They both tend to be partially evergreen, but this is hardly an advantage because the old leaves look quite messy by spring. The latter species, mostly represented in cultivation by var. *colchicum*, is the more ornamental of the two. The flowers with yellow sepals and paler, spurred petals appear before the leaves are well developed on inflorescences about a foot tall. *Epimedium perralderianum* is somewhat shorter than the preceding species, and the flowers are a brighter yellow throughout. Unfortunately they are somewhat hidden by the leaves.

The rhizomatous *Epimedium alpinum* from southern Europe is much rarer in cultivation than its hybrid with *E. grandiflorum*. This plant, *E.* × *rubrum*, is tightly clump-forming. Its flowers are among the most ornamental in the genus, the sepals being crimson and contrasting nicely with the conspicuous but not protruding spurs. The foliage is also exceptionally ornamental with the heart-shaped leaflets edged and veined with red, at least when young.

A number of very fine Chinese species are not in cultivation, but hopefully they will eventually find their way into our gardens. One in particular appears desirable from available descriptions. *Epimedium acuminatum* may stand 18 inches tall when in flower, with leaflets as much as 6 inches long and flowers 1½ inch across.

Epimediums are useful in situations other than the wildflower garden. They do well in any decent soil, and they can tolerate nearly full sun to dense evergreen shade. High or partial shade is preferable, however, to prevent burning of the foliage and to allow for good flowering.

The last genus included here is often classified in the Crowfoot Family (Ranunculaceae). *Glaucidium palmatum*, the so-called Blue Japanese Poppy (not a poppy at all), is restricted to Japan, and is the only species of its genus. It is a truly spectacular plant with its 3- to 5-inch, pale blue-lavender flowers and its bold, coarsely lobed leaves. The aspect of the plant is much like that of *Podophyllum* and *Diphylleia*, making it a valuable accent specimen in the wildflower garden even after it has passed out of bloom. Well grown plants stand about 15 inches tall at maturity, and the leaves are as much as 10 inches across. Once established, *G. palmatum* is vigorous and hardy, thriving in partial shade. It is easily grown from seed, germination proceeding after a cold stratification period of two months. The plants will flower after about four years.

The Heath Family (Ericaceae) consists primarily of woody plants, and even the single genus discussed here would be considered a shrublet. *Epigaea repens*, the Trailing Arbutus, or Mayflower to New

Plates reprinted with permission from Curtis's Botanical Magazine *are, clockwise from top left*: Epimedium grandiflorum [*as* E. violaceum] (*Vol. 66, 1840*); Epigaea asiatica (*Vol. 154, 1928*); Glaucidium palmatum (*Vol. 159, 1936*); Dryosma pleiantha [*as* Podophyllum pleianthum] (*Vol. 116, 1890*).

Cymbidium goeringii. *Reprinted with permission from* Curtis's Botanical Magazine, *New Series, Vol. 174, 1962.*

Englanders, with its extremely fragrant, white to pink flowers, is one of our best-loved wildflowers. It is a common plant in open, dryish woodlands throughout the Appalachian region. Unfortunately this plant is notoriously difficult to cultivate in gardens. Insufficient sunshine and too much water about the roots are probably the most common causes of failure. It is also very difficult to transplant, even if seedlings are taken with a clump of earth, and only pot-grown plants started from seeds or cuttings would be recommended for the average gardener.

The Japanese counterpart, *Epigaea asiatica*, is a rare plant in cultivation. It differs from our native species in its narrower, more pointed leaves; its more tubular, less fragrant flowers; and in not being dioecious (with separate male and female plants). It is hardy here in New England with some protection, but it should be planted in a cool, shady situation. It is by no means an easy plant, but the clump in front of the cold storage unit of the Dana Greenhouses here at the Arnold Arboretum has prospered and flowered well for a number of years.

Arisaema urashima. *Photo: R. Weaver.*

A hybrid between the above species has been known for a long time, but it has probably disappeared from cultivation. Its recreation and propagation would be most welcome.

Nursery Sources

Alpines West, Rte. 2, Box 259, Spokane, Washington 99207 — *Cypripedium, Disporum, Goodyera, Trillium.*

Gardens of the Blue Ridge, Ashford, North Carolina 28603 — *Clintonia, Cypripedium, Diphylleia, Disporum, Liparis, Stenanthium, Trillium.*

Griffey's Nursery, Marshall, North Carolina 28753 — same as above.

Edgar L. Kline, 17495 S.W. Bryant Road, Lake Grove, Oregon 97034 — *Clintonia, Cypripedium, Disporum, Glaucidium, Scoliopus, Trillium, Vancouveria.*

J.A. Mars of Haslemere, Haslemere, Surrey, GU27 3DW, England — *Cypripedium, Trillium.*

Mr. Tatsuo Niizuma, 6–10, Yamate-2-chome, Nakasuji, Takarazuka, Hyogo 665, Japan — mostly orchids, but other genera on request.

Siskiyou Rare Plant Nursery, 522 Franquette Street, Medford, Oregon — *Clintonia, Cypripedium, Disporum, Epimedium, Scoliopus, Trillium, Vancouveria.*

Hemerocallis *'Little Hustler', a melon-colored dwarf diploid. Photo: G. Pride.*

Today's Daylilies

by George H. Pride

A Hemerocallis show twenty-five or thirty years ago featured flowers mostly in shades of yellow and orange. Other colors were rarely seen. A modern daylily exhibition has classes for the following colors or color patterns: Near white, yellow, orange, pink, peach, melon, rose, bright red, orange-red, dark red, lavender and purple, polychromes, bicolors, and eyed. True blue and pure white are about the only colors missing. The show includes classes for large-, small-, and miniature-flowered varieties. There is a class for "spider-flowered" types that have long thin floral segments and a class for "double" flowers. A section for dwarf cultivars is usually added for daylilies that normally grow under 24 inches in height. Two recent developments will probably have to be included soon: New cultivars are appearing with deeper colored contrasty margins on the flower segments, a pattern known as "picotee"; and for several years now there have been daylilies with lacy fringing along the edges of the petals creating an attractive and novel appearance.

One reason for the rapid increase in popularity of these new plants is their relative ease of cultivation. They thrive in ordinary garden soil in a location receiving at least a half day of sunshine. Though they can stand long periods of drought, they grow best and have more flowers when they are kept well watered. Few if any serious pests or diseases seem to bother them.

All wild species of daylilies are native to Asia, mainly China and Japan. They have been cultivated in China for hundreds of years for medicine and as vegetables. A translation of an account written in China in 656 A.D. states that *Hemerocallis* "quiets the five viscera (the heart, lungs, liver, kidneys, and stomach), benefits the mind and strengthens the will power, gives happiness, reduces worry, lightens the body weight and brightens the eye."

Dr. Shiu Ying Hu, formerly of the Arnold Arboretum staff, and an authority on the taxonomy and lore of these plants, states that the written Chinese character for daylilies is the same as that for "mother love." The dried buds known as "golden needles," and available in Chinese stores in most large cities, are used in cooking. The roots and crown of the plants also are used for culinary purposes, and as a pain reliever. A hallucinating effect is said to occur when a lot of young shoots are eaten, giving the sensation of "feeling no pain." The flavor of the cooked plants is described as like that of creamed onions.

Unfortunately labelled "Tiger Lily" flowers, these are the dried daylily buds known as "golden needles" and used in Chinese cooking. Photo: R. Howard.

Horticulturally, the modern daylilies of our gardens are unique in several ways: A relatively few species have led to a remarkable diversity of types and flower colors; this galaxy was created in a relatively short time; and daylilies are one of the few major garden subjects that originated in China and were not first developed beyond the species stage by the Chinese. (Except for the very earliest work, most of the breeding has been done in the United States.)

Species from which this new race of garden plants has so rapidly developed include *Hemerocallis citrina* from China, whose large fragrant lemon-yellow flowers unfurl in late afternoon, remaining open all night. (In breeding this acts as a dominant characteristic.) *H. middendorffi* is a dwarf plant producing fragrant orange flowers of very firm texture in late spring. *H. thunbergi* from Japan is a robust grower bearing many fragrant lemon-yellow flowers in mid- to late season. It has been widely used in hybridizing. *H. aurantiaca*, also from Japan, with fragrant bright orange flowers sometimes flushed purple helped produce darker colors in the breeding work; it and *H. thunbergi* were used extensively by the early breeders. *H. lilioasphodelus* (*H. flava*), the Lemon Lily, is spring flowering and is still widely grown as a popular garden plant; in 1848, Asa Gray noted that it was "extensively cultivated." *H. fulva*, with tawny-colored flowers,

has been known in the West since 1576. Thomas Nuttall, in 1818, distributed it around Philadelphia so thoroughly that it appeared to be naturalized. It is certainly the most widely cultivated daylily in the world today (probably all the plants are the cultivar 'Europa'). It is a highly sterile, self incompatible triploid. Despite this, through extensive and persistent breeding work it did give rise to a few important seedlings. Its tenacity on life is legendary. Portions of plants have been buried 40 inches deep in soil and have survived, producing long rhizomes that emerged from the top of the heap and developed into healthy plants. An edition of *Gray's Flora* published in 1848 lists it as a common escapee. The double flowered cultivar of this species, known as 'Kwanso', and a green and white-leaved double flowered cultivar known as 'Kwanso Variegata' still fascinate many gardeners. *H. minor*, the Dwarf Yellow Daylily, is an early flowering species with fragrant yellow flowers. Charles Sargent, the first Director of the Arnold Arboretum, reported it growing in his Brookline garden in 1895 and recommended it highly. *H. multiflora*, first described in 1929, has numerous small orange flowers later in the season. A well-known cultivar developed from it is called 'Tinkerbell'.

In the late 1800s the first daylily breeding work began in England. The first cultivar, named by George Yeld in 1892, was 'Apricot' — probably a cross between *H. lilioasphodelus* and *H. middendorffi*. Sporadic work continued in England, but nothing we would now consider remarkable appeared. The new cultivars were moderately popular garden subjects, but similar in color, being mostly yellow and shades of orange.

Breeding work in daylilies started in America mainly as a result of cooperation between Dr. Albert Steward, who was a teacher of botany at the University of Nanking from 1921 to 1950, and his close friend, Dr. Arlow Stout of the New York Botanical Garden. Dr. Steward was highly regarded by the Chinese and was readily admitted to many gardens and farmyards where he found interesting "forms" of daylilies. These were sent to Dr. Stout for his consideration and to be used in his breeding work. Perhaps, from the gardening standpoint, the most important plant of all was *H. fulva* var. *rosea*, which had rose-colored flowers. The first specimens of this variety were sent from China in 1924. When the chromosomes of this variety were counted it was found to be a diploid, making it much easier to use in breeding than the triploid cultivar 'Europa'. A seedling named 'Rosalind' resulting from Dr. Stout's work with this variety had rose-red flowers and helped unlock a vast array of new colors in daylily breeding.

During the forty-one years between 1893 and 1934, only twenty-three hybridizers were known to be working with daylilies, producing a total of one hundred seventy-four cultivars or an average of only four a year with no great change in flower color evident. With the availability of the new species and their variants that Steward sent

Left: Hemerocallis fulva (*Tawny Daylily*). *From* The Botanical Magazine, *Vol. 2, 1790. Right*: Hemerocallis fulva *var.* rosea. *From* Addisonia, *Vol. 15, 1930.*

to Stout, many colors not seen before began to emerge. During a period of only fourteen years, from 1934 to 1948, the American Hemerocallis Society registered 2,278 new cultivars, an average of one hundred fifty a year; but from 1948 to 1966, a period of eighteen years, 10,145 new cultivars were registered, averaging around five hundred fifty a year. During the last ten years the average number per year of newly registered kinds has been seven hundred thirty-four. In 1975, more than one hundred fifty active daylily breeders were listed in the American Hemerocallis Society's registry. Since this society started in 1946, known then as the Midwest Hemerocallis Society, it has registered over twenty thousand cultivars.

With daylilies' skyrocketing popularity already underway, a remarkable new development in their breeding occurred in the middle 1940s when the first man-made tetraploids appeared. Up to that time most cultivars had been diploids with a normal set of twenty-two chromosomes in each somatic or body cell of the plant; each gamete or sex cell contained eleven of these structures.

Hemerocallis *'Frances Fay', with diploid form on the left and tetraploid at right. Photo: G. Pride.*

The tetraploids were developed as a result of the use of the chemical, colchicine, which is obtained from the *Colchicum* or Fall Crocus. (Colchicine is a well-known agent for developing polyploidy in plant tissues.) The tetraploids have forty-four chromosomes in each body cell — four times the number in a sex cell of a diploid variety, which accounts for the prefix "tetra."

There seems to be confusion about who should be considered first in bringing about this radical change in what was already a popular garden plant. According to the best information available, the first tetraploid daylily flowered in 1947, and was the result of the work of Robert Schreiner, a student at the University of Minnesota. Mr. Schreiner flowered several tetraploid clones that year, and a treated plant of the cultivar 'Cressida' was named 'Brilliant Glow'. In 1948, more tetraploid daylilies were flowered at the University of California in Los Angeles; these were the results of work by Quinn Buck. Over the years much daylily breeding has been done at the United States Department of Agriculture in Beltsville, Maryland. In 1951, Dr. Hamilton Traub gave detailed descriptions of his experiments there. In 1949, he flowered what he described as a "complete tet" and named it 'Tetra Starzynski'. The term "complete" indicates that the plant is completely tetraploid. When colchicine is administered to a grown plant or seedling, there is a very high possibility that the result will be a "chimaera" with some tissue diploid and some tetraploid. Much more desirable for breeding work is the "complete" tetraploid. By 1959, sixteen named tetraploids bred by Dr. Traub were introduced to the gardening public at prices ranging from $65.00 to $500.00 a plant. The race was on!

People were confounded by this extraordinary development and the prices being asked for the plants. All the Traub introductions were "evergreens," which do better in the southern states than in the north because they have a tendency to continue to grow and not die down to rest during the winter, even after frosts have killed them back. (This usually results in enough damage to the plant tissues to cause the plants to do poorly the next season.)

In the 1950s, Dr. Robert Griesbach and Orville Fay teamed their efforts and treated many diploid seedlings with colchicine. By 1959 they had flowered around one hundred tetraploids. In 1961, four tetraploids were introduced: 'Crestwood Ann', 'Crestwood Bicolor', 'Crestwood Evening', and 'Crestwood Lucy'. In 1963, the Griesbach-Fay team added 'Crestwood Gold' to the roster; and in 1967, 'Mary Todd' and 'Golden Surrey'. The latter was the first known daylily with a pronounced lacy fringing on the petals. All these cultivars were "dormant;" when the cold came they died down and rested until spring when new growth started. They were, therefore, more suitable for northern gardens.

More and more researchers became involved. It is only possible to name a few of them here, which means slighting a great many others. In 1964, Dr. Toru Arisumi at Beltsville reported converting seventeen diploid cultivars to the tetraploid condition. In Illinois, Brother Charles Reckamp's work was notable for the production of many new tetraploids in shades of yellow and so-called melon colors. Drs. Virginia and Richard Peck, two college professors who taught English in Tennessee, started intensive work in the 1960s. The results are still bearing fruit. Soon there were hundreds of dedicated amateurs and professionals who were deeply involved with work on this new type of plant. In New England alone, several growers started work with colchicine more than fifteen years ago with excellent results. A whole series of tetraploid daylilies has been developed especially suited to this climate. And yet, by 1967 from all of the United States only sixty-six tetraploids that had been grown from seed, and seventeen that had been induced by the use of colchicine, had been registered by the American Hemerocallis Society.

The differences in the tetraploids and diploids were striking even to the non-scientist. In most cases the petals of the flowers were larger and heavier textured. Flower buds and flower stalks were thicker in diameter and the colors of the flowers were deeper and richer than before. Pollen grains examined under a microscope were seen to be noticeably larger. The leaf pores or stomates were fewer, but larger by about ⅓. The illustration accompanying this article of the diploid and tetraploid cultivars of 'Frances Fay' will give some idea of the obvious differences. The conversion work in this case was done by William Lachman of Amherst, Massachusetts who has been especially active in this field.

Left: Hemerocallis *'Love Is', an unintroduced tetraploid developed by Donald Stevens.*
Photo: L. Mitchell.

Right: H. *'Dawn Ballet', a light polychrome tetraploid.*
Photo: G. Pride.

Left: H. *'El Tigre', an eyed tetraploid.*
Photo: G. Pride.

Originally there was much discussion among gardeners as to whether or not the new tetraploids were as superior as was being claimed. Now most Hemerocallis growers seem to be convinced that they are a decided advancement both as a garden subject and as a show flower. Some gardeners have abandoned the diploid cultivars and are now growing almost exclusively the newer tetraploids. Jokingly referred to as the "Tet Set," they are strong in their praises of the new tetraploid daylily cultivars.

Perhaps the greatest advance in making these plants even more available to the average gardener is tissue culture, which is going on at the present time. Hemerocallis are especially adapted to this process, which is bringing radical changes in the speed of plant propagation. In the last few years, several researchers, including Dr. Martin Meyer of Urbana, Illinois and Dr. Abraham Krikorian of Stony Brook, New York, have shown that by using very small pieces of the undeveloped buds and inflorescence stems one can increase the number of plants from a single specimen astronomically. The proper techniques are well understood, but are not easy for the amateur as they involve a laboratory similar to one used for growing bacteria, and completely sterile conditions. Claims of a potential of several hundred thousand plants produced in less than a year from the tissues of one plant are being made. A new film that the Arnold Arboretum has just completed dealing with plant propagation features this process in some scenes. It may be only a short time before a new, very choice daylily which would have been introduced in the past for from $50.00 to $100.00 will be available to the gardener in quantity for only a few dollars a plant.

There are several gardens not far from Boston where many of these exciting new tetraploids may be seen. A collection has been established at that part of the Arnold Arboretum known as the Case Estates in the town of Weston. Two commercial growers in Massachusetts have quantities of these cultivars. They are Robert Seawright, 134 Indian Hill, Carlisle, and Charles Trommer, 45 River Street, Rehoboth.

A dozen or so non-commercial gardeners have excellent collections that may be seen by visitors. One might check the membership roster published in the Journal of the American Hemerocallis Society to locate members nearby and request permission to see their new daylilies. This list is on file at the library of the Arnold Arboretum in Jamaica Plain.

Another way to see many of the newest daylilies is to visit a horticultural show featuring them. For many years, the Worcester County Horticultural Society, Elm Street, Worcester, Massachusetts has held one of the finest daylily shows in the world. One day only, it is usually on the last Saturday of July. It would be wise to call the Society and check before visiting.

Hemerocallis *'Kindly Light', a diploid, spider type. Photo: G. Pride.*

With all that has been accomplished so far in such a short time, it is hard to believe that daylily breeders are still unsatisfied. They are now concentrating on clearer colors, and the production of a pure white and a true blue daylily. Improvement in early flowering types is being sought. There is hope for many more cultivars with flowers that stay open at night for indoor decoration, and even that a daylily with flowers lasting two days may yet appear. Startling picotee edges are showing up on some of the new cultivars. Reblooming or remontant varieties are being used extensively in hope of producing an everblooming daylily that would start to flower in the spring and continue until stopped by frost.

Fragrance has been neglected. Many gardeners are hoping for more varieties with pleasant scents. Some of the night-flowering yellow daylilies are noticeably fragrant; other cultivars have no fragrance at all. This is apt to be true of the red and purple varieties. The scent occurs only when the flower is open and comes from special "scent cells" widely distributed over the inside of the petals.

The daylilies of the future may have all these desirable characteristics, and new methods of propagation will make the plants available in great quantity at very reasonable prices. The components needed for such marvels are available now. All that is necessary is the wizardry of the plant breeder to assemble them in the proper manner.

Hemerocallis *'Chicago Picotee Promise', a recent development in tetraploids featuring a striking eye zone. Photo: Courtesy, George Lennington.*

Author's Favorite Fifty Regardless of Price
(all are tetraploids except where noted)

SHADES OF RED
Barbarossa (Peck) bright red
Bruce (Pride) orange-red
Chicago Rosey (Marsh) rosey-red
Cherry Cheeks (Peck) rose-red
Dragon Lore (Peck) rich medium red
Ed Murray (tet. form) (Grovatt) black-red
Firedrake (Peck) rich red
Howard Goodson (Griesbach) medium red
Joey Langdon (Griesbach) bright red
Lusty Leland (Peck) bright red
Rubric (Griesbach) red with green throat
Scarlock (Peck) bright red
Slowly Won (Peck) bright red
Turned On (Pride) firey-red
Wine Bold (Peck) wine-red

POLYCHROMES
Dawn Ballet (Reckamp) light blend
Heavenly Harp (Reckamp) light blend
Prides Crossing (Pride) light blend

VARIOUS
Highland Lass (Peck) bicolor
Heather Green (Peck) pink with green throat
King Alfred (Reckamp) double yellow
Little Hustler (Pride) dwarf yellow diploid
Mary Moldovan (Moldovan) melon
Ruffled Apricot (Baker) name describes it
Rose Revue (Griesbach) medium rose
Sable Night (tet. form) (Wild-Hardy) deep chocolate
Segramoor (Peck) wine
Thai Ballet (Moldovan) cerise

SHADES OF YELLOW
Erin Prairie (Fay) greenish-yellow
Evening Bell (Peck) light yellow
Golden Prize (Peck) deep yellow
Hudson Valley (Peck) large light yellow
Ice Follies (Pride) very pale yellow
Mary Todd (Fay) gold
Royal Kin (Peck) light yellow
Orange Prelude (McEwen) very early orange
Yellow Crystal (Griesbach) medium yellow

EYED
Brindlee Beauty (Webster) pale eye zone
Chicago Maid (Marsh) striking eye zone
El Tigre (Durio) medium eye zone
Kempion (Peck) light eye zone
Thumbprint (Peck) odd patterns

LAVENDER AND PURPLE SHADES
Aberdeen (Peck) very pale lavender
Chicago Bride (Marsh) pale bluish-lavender
Chicago Queen (Marsh) lavender-purple
Helen Boehm (Peck) pale lavender
Rum Plum (Pride) purple

FRINGED PETALS
Chicago Knobby (Marsh) purple with "knobbed" petals
Creepy Crawler (Hite) yellow with pronounced fringing
Golden Surrey (Griesbach-Fay) yellow with fine fringing

NOTES FROM THE ARNOLD ARBORETUM

"Flowers - Art or Science?"

by Margo W. Reynolds

The Arnold Arboretum means differing things to its various publics. To some, it is an institution devoted to the scientific investigation of plants. To others, it is an oasis of green in the urban sprawl of Boston; a place where plants can be enjoyed and admired for their aesthetic merits.

This spring, in an unusual exhibit entitled "Flowers — Art or Science?", Belmont artist Eudoxia Woodward attempted to answer that question and ascertain if plants could, indeed, bridge the gap between art and science. Well over forty sketches and watercolors illustrated Mrs. Woodward's belief that science and art are not incompatible in an understanding and appreciation of botany. As she explained in her April 13 gallery talk:

> For the past few years I have been exploring some universal concepts found in nature; spirals, helices, conic sections and symmetry. Through close examination of (plants), I continue to find examples of the "divine laws of nature." I also find endless pleasure in looking at and recording their structure and growth. In my paintings I hope to transmit my excitement about these laws and, by bringing together science and art, lessen the bridge that exists between them.

Visitors to the month-long exhibit came away with a new perception of art, botany and mathematics, and were treated to an exhibit both educationally and aesthetically rewarding.

Rieger Begonia illustrating the mathematical concepts of spiralling, where the path of a point (generally on a plane) moves around an axis while continually receding from (or approaching) it. Painting by Eudoxia Woodward.

ARNOLDIA REVIEWS

The Thompson Begonia Guide, second edition. Mildred L. and Edward J. Thompson. P.O. Drawer PP, Southampton, N.Y.: Edward J. Thompson. Three volumes, illustrated. Vol. I, $18.50, plus $1.25 (shipping costs); Vol. II, $17.50, plus $1.25; Vol. III, $23.25, plus $1.50. Revision sheets, $1.25.*

Until now, anyone interested in learning about begonia culture has found it almost impossible to locate much information that is pertinent and available. Most of the books devoted to growing begonias are out of print and dated. One cannot even buy an inexpensive beginner's pamphlet such as those available for orchid and gesneriad growers. In 1975, the American Begonia Society published a translation of Chevalier's *Begonias*. Written in 1938, this work offers much information of historical and taxonomic interest but obviously lacks the information on soils, fertilizers and light that has been learned in the intervening thirty-nine years.

Even if there were not this appalling lack of information on begonia culture, *The Thompson Begonia Guide* would still have to be considered a major contribution to horticultural literature. It is a comprehensive work that satisfies all levels of amateur growing. The beginner simply wants to know how to keep the plants alive and healthy, whereas the more sophisticated grower is interested in producing plants for show. The very advanced begonia enthusiast often wants to hybridize or venture into taxonomy. *The Thompson Begonia Guide*, happily, is a reference book to grow with, for the information in the three-volume set is for all levels of expertise, and the loose-leaf format allows revision sheets to be inserted as they become available.

The guide is organized around the concept that begonias with similar characteristics and growth habits have similar cultural requirements. On this basis, 1800 species and cultivars have been classified into horticultural groups and alphabetized in the guide. The information on potting soils, light, humidity, watering and care is clear and practical. A good mixture of photographs and drawings clearly shows the "how to" of every aspect of growing from potting to propagation.

* *Because of its significance to both horticulturists and botanists,* **The Thompson Begonia Guide** *is being reviewed by a representative of each group. Corliss Engle, a Friend of the Arnold Arboretum, is an experienced amateur grower and past President of the Buxton Branch of the American Begonia Society. Bernice G. Schubert, a member of the staff of the Arnold Arboretum, is Curator and Senior Lecturer on Biology, with a special interest in Begoniaceae.* **Ed.**

Because success in growing is an art, at best, based on experience, locale and style, the Thompsons have included articles by begonia growers from various sections of this country and around the world. Each article offers tips applicable to each region; common truths weave their threads in combination with the specifics. In addition, there are excellent articles on special growing areas, such as windowsills, artificial lights, etc., written by experts.

The more advanced growers will find a wealth of information, again with excellent graphics, on growing begonias for exhibition. The sections on terrariums, growing begonias on rocks or driftwood, and hangers are especially good.

The sophisticated amateur grower will find the sections dealing with bloom information, parentages of hybrids, and the extensive references to sources of information written about each begonia (not otherwise available) helpful and well organized. The reproduction of old begonia prints and the historical section will fascinate any amateur grower.

Millie and Ed Thompson have long been known as growers of spectacular begonia specimens. With this guide, all begonia fanciers will at long last reap the benefits of their knowledge and experience.

Corliss K. Engle

The Thompson Begonia Guide is a very impressive, though unorthodox, document assembled with good taste and complete dedication by the Thompsons, who consider themselves hobbyist-growers and who have other unrelated, full-time careers. Its chief interest, for botanists, is the clearly presented information concerning those members of the Begoniaceae that are in cultivation. This material is not so easily available in as great detail anywhere else to my knowledge.

Volume I includes an alphabetical listing (A) of all species, hybrids, and cultivars known to be in cultivation; a horticultural Classification Listing (CS) in which the taxa are classified by the habit of the plants (cane-like, shrub-like, tuberous, rhizomatous, semperflorens characteristics, rex cultorum, etc.), an artificial but useful grouping since begonias with similar habit have, in general, similar cultural requirements. Also included is a Parentages of Hybrids (P) section, containing information not often compiled with such completeness.

In Volume II a section on Bloom Information (B) lists species and cultivars separately and indicates flower color, flowering period, and amount of flowering. This section also includes some excellent photographs of both individual flowers and of inflorescences of various species and cultivars. Volume III is devoted almost completely to the interests of Begonia growers, but includes a fine Pictorial Re-

view (R) with 72 pages of photographs of species and cultivars. The volume is concluded with an enlarged and completely revised Bibliography (Bi), superceding the one in Volume I.

The symbols in parentheses following the section names appear on each page of the appropriate section, followed by the page number. That is, each section (seven in Volume I, five in Volume II, and four in Volume III, plus introductory matter for each volume) is separately paged making for extreme awkwardness in citation, and the impossibility of a general index. I think that if the symbols followed the page number and the pagination were continuous, much of this awkwardness would disappear.

The order in which the various taxa are considered in the Classification Listing section (C) follows that spelled out and illustrated in the section on the Classification System (CS). Much more information is included here for each taxon listed. However, there are various new symbols and abbreviations in such profusion that checking each one makes the task of acquiring the complete information complicated and time-consuming. The method of citing references by symbols does not follow any earlier formulated system I know of, either botanical or bibliographic, so mastering the "mechanics" of the section must be undertaken. The system seems a bit wasteful, also, in that the bibliography is listed at the beginning of the section (with the symbols) and again at the end of the volume in its own section (Bi). In addition, a revised bibliography occurs at the end of the volume (where most pages are dated April, 1977). A bibliography at the end with each entry numbered would obviate the need for the earlier list and all the symbols. The references could then be referred to simply by number.

The Classification Listing section (C) is 146 pages long and is of much interest to botanists because it presents the horticultural classification of each of various species of Begoniaceae considered in the

Guide and also lists the hybrids in each of the categories. This is very useful information obtained through long searching and much interchange with growers. It is a real contribution.

The Parentages of Hybrids section (P) is another extremely useful portion of the Thompson guide and surely must have been one of the most difficult to compile. Through the efforts of the Thompsons and other contributors to the *Begonian*, most growers of begonias have now become aware of the necessity of keeping records of the hybrids they produce. Until very recently, however, this has not been the case, making it difficult for botanists to identify these plants correctly or to duplicate the crosses.

The section called Glossary of Descriptive Botanical Terms (G) comprises a list of definitions compiled from various sources, "formulated for the grower and geared to his needs." The effort to modify definitions for the grower has, unfortunately, led to oversimplification and inaccuracies. A few examples will suffice to indicate the kind of trap into which one may fall. In the list below, the line following the term is the definition as given in the Guide. The line directly below, starting with a capital letter, is a correction and/or explanation.

androecium
reproductive portion of male flower composed of one or more stamens
The androecium is also the "male" element of a perfect (bisexual) flower.

dichotomous
divided in two parts
Dichotomous, in botany, implies *forking* into more or less equal parts.

dioecious
unisexual
Unisexual with staminate and pistillate flowers on different plants.

gynoecium
reproductive portion of a female flower
The gynoecium may be the "female" portion of a perfect (bisexual) flower also.

indigen
naturalized plant
An indigenous plant, i.e., a native.

isotype
form common to the holotype
An isotype is any duplicate (part of a single gathering made by a collector at one time) of the holotype; it is always a specimen. [International Code of Botanical Nomenclature — Article 7.]

perianth
floral envelope
The two floral envelopes considered together; a collective term for the calyx and corolla.

stamen
the pollen bearing organs of a male flower

Begonia versicolor. *From* The Thompson Begonia Guide, *Vol. III. Drawing by Rosemary D'Andrea.*

> The stamens are the pollen bearing organs of any flower in which they occur, e.g., perfect (bisexual) flowers.

A term important in botanical descriptions of Begonias, which does not occur in the original or revised list (5/15/76), is *tepal*, used for a segment or unit of a perianth that is not clearly differentiated into calyx and corolla (i.e., sepals and petals), the usual case in Begonia flowers. Tepal has been insterted in the Addenda (G-15), dated 10/1/76, and is defined as "petal," an unsatisfactory equivalent.

The sections of the Guide in Volume II which I have not discussed in any detail include Historical Excerpts (H), Cultural Listings (L), and Propagation (PR). Those in Volume III include Culture of Begonia (CB), a section of 277 pages, profusely illustrated; Pictorial Review (R), an excellent set of photographs arranged by the horticultural classification groups; the Appendixes A and B (Ap); and the revised and enlarged Bibliography (Bi).

The section of Historical Excerpts is replete with interesting information from various periods in the collection and study of Begoniaceae and of botanical research on them. Translations of the excerpts not in English are an additional bonus. The horticultural reproductions in this series will also be of much interest to those not having access to such literature. The efforts of the Thompsons in amassing such a fine collection of reproductions is an indication of their deep interest and thorough devotion to the study of Begoniaceae.

The Cultural listings (L) are arranged so that Begonias may be chosen according to the light, space, and equipment they require. Subdivisions indicate which plants are best for beginners and/or more experienced enthusiasts.

The Propagation section (PR) covers in a clear, detailed, and well illustrated manner what seems to be complete information on stem cuttings, leaf cuttings, and propagation by seeds. It sounds as if anyone with a will to try these procedures could accomplish his objectives.

Volume III, which is concerned almost entirely with Culture of Begonias (CB) and the Pictorial Review (R), needs little comment from someone as inexperienced in growing these plants as I. However, the possibilities are numerous, challenging, and interesting and should draw many more adherents into the rapidly growing group of Begonia enthusiasts.

These three volumes of *The Thompson Begonia Guide* are large (29.5 × 10.5 cm.), hard cover books reproduced by a good quality photo-offset process. For the future I should like to think that the bulk of the volumes might be somewhat reduced and a single-volume "real" book be prepared which would have all the basic information and be somewhat easier to handle. In the meantime many people should derive great pleasure and satisfaction from enjoying Begonias with the Thompsons.

BERNICE G. SCHUBERT

Hemerocallis *'Mary Moldovan', a melon-colored tetraploid. Photo: G. Pride.*

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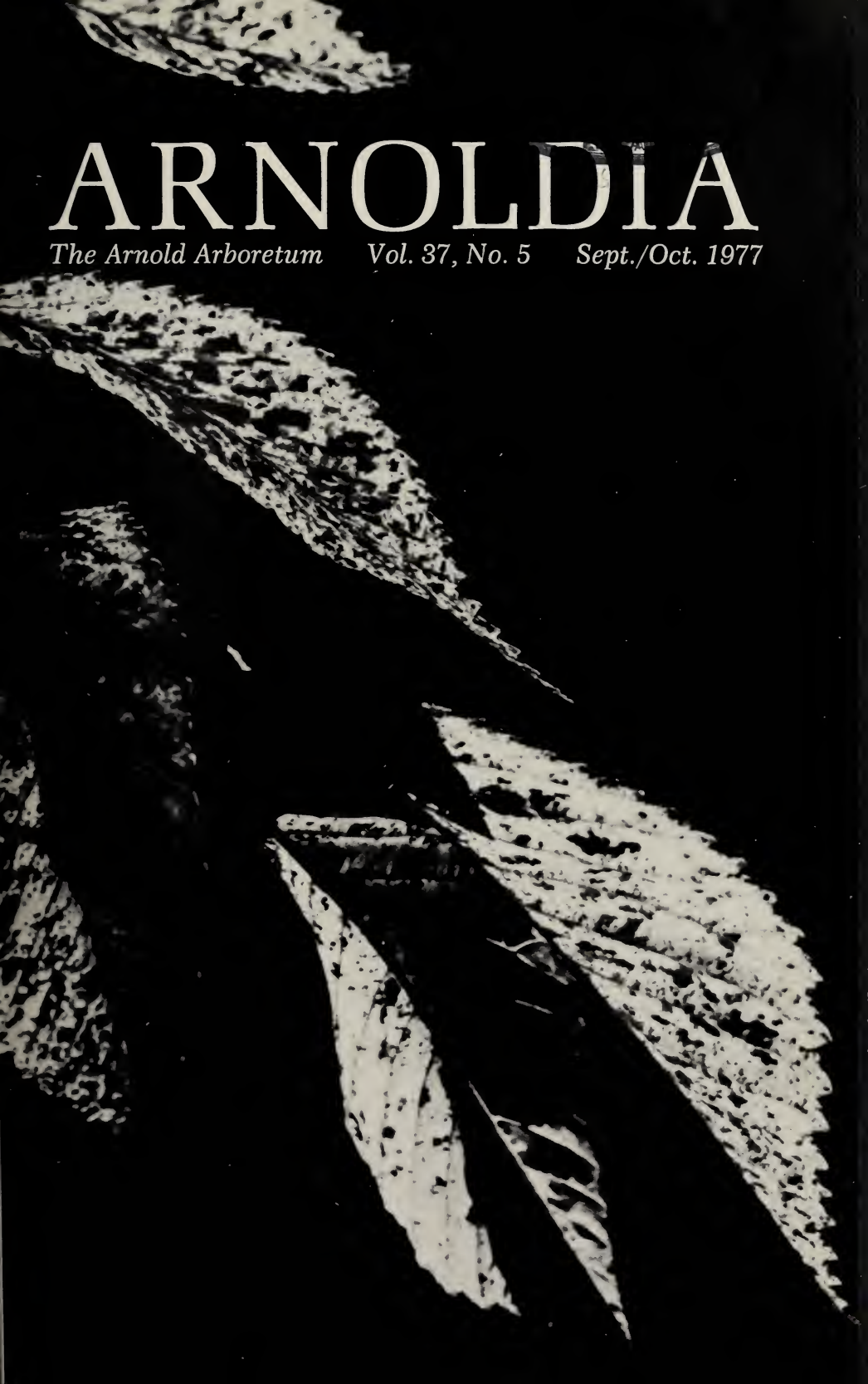

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Balloon Flowers, Bladdernuts and Rattle-boxes

by Richard A. Howard

Many plants trap air or hold gases within their tissues resulting in inflated or swollen stems, leaves, flowers or fruits. The value of this characteristic in the survival of the plant is readily observed in some, but remains unclear in others.

An inflated calyx, corolla or inflorescence axis may be more conspicuous and aid in attracting pollinators, although this supposition may be pure speculation on the part of the human observer. However, the inflated calyx surrounding a fruit, or the inflated fruit itself aids in the dispersal of the plant as the swollen part of the plant rolls along the ground or is carried in streams or ocean currents.

A few aquatic plants may have stems, leaf blades or petioles with spongy, air-filled tissue that enables the plant to float and so be blown about the water surface by wind or carried by currents. It would appear to be an easy matter to extract a sample of the gas from within the plant tissue and analyze it. Apparently this has never been done, for no reference to the composition of the gas can be found in modern literature. One can only speculate that it is an air mixture, possibly heavily laden with carbon dioxide, possibly generated within the plant from the process of respiration.

In some plant parts the gas is under considerable pressure and so the swollen corolla or fruit is not alone the result of growth, but of turgidity. When pressed by hand, the organ may rupture or explode with a respectable noise, as observed in the Firecracker Plant. In other plants, the swollen calyx or seemingly inflated fruit may occur by growth alone without the trapping of gas, as evidenced by an opening or orifice to the calyx or the fruit.

The leaves of water lilies float because they trap gas in open spaces between the living cells of the leaf blade. Large air-filled cells occur in the Water Lettuce enabling the rosette of short stem and thick flat leaves to support the plant on the surface of the water. Finger pressure on the leaves may reduce their thickness to one-tenth of their natural size. The petioles of the Water Hyacinth contain air and are swollen, enabling this plant to float while extending the leaf blades well above the water surface. In military survival manuals the Water Hyacinth leaves and petioles are recommended as a green vegetable. When deep fried, the spongy petioles retain the crispness of corn crisps and have been used as an unusual hors d'oeuvre.

Plants that have developed swollen or inflated parts are found in many families and are among our cultivated garden plants. They are not only attractive and unusual, but subjects of conversation. Many have been used in dried arrangements or wreaths. Their names are often descriptive of the inflated condition, as for example the scientific name of the Desert Candle, *Caulanthus inflatus*. This plant is native to California and a member of the Mustard Family. The swollen hollow stem bears leaves below and flowers above, and a field of these plants in flower is an unusual sight of erect flowering stalks. *Lobelia inflata*, also known as the Indian Tobacco, has a swollen fruit in which the many small seeds are free to rattle when mature. The common names of Balloon Flower, Balloon Vine, Bladdernut or Chinese Lantern Plant also suggest some unusual characteristic.

Some of the more common plants with inflated parts are discussed below according to the inflated part.

Inflated Calyx

Spathodia campanulata. African Tulip Tree. Bignoniaceae. Native to Africa.

This is a large tree of tropical Africa now cultivated in Florida, Hawaii and the tropics of both hemispheres. The bright red-orange flowers, slightly compressed and asymmetrical, have a brilliant margin of gold on the corolla. The calyx is similarly shaped, pubescent, and golden. Glands inside the calyx normally secrete a liquid, and when the young swollen calyx is pressed the secretion may squirt several feet from the pointed apex. Occasionally the calyx may contain a little or great amount of air and actually explode when pressed.

Silene cucubalus. Bladder Campion. Caryophyllaceae. Native to Europe.

Lychnis alba. White Campion. Caryophyllaceae. Native to Europe.

These are two of several members of the Pink Family that have become naturalized in the United States and often occur as weeds in northern gardens. The calyx is inflated in flower and continues to increase in size as the fruit develops. When young, the lobes of the calyx may be tightly appressed, but never tightly enough to hold gas. The mature capsule is enclosed in the swollen calyx which is clearly separated from the capsule.

Swollen Corolla

Platycodon grandiflorum. Balloon Flower. Campanulaceae. Native to E. Asia.

An old-fashioned garden perennial with a swollen turnip-shaped corolla, blue-gray on the outside and eventually opening fully to reveal a vivid blue color inside. White-colored flower forms are known.

Hernandia ovigera. *a. Whole fruit in expanded receptacle; b. from above; c. receptacle split open showing ribbed fruit.* Bixa orellana. *d. Habit of fruit cluster.* Spathodia campanulata. *e. Cluster of flowers with curved calyx. Drawing: Robin S. Lefberg.*

The corolla swells as the flower develops and before opening is turgid and may pop when pressed.

Russelia equisetiformis. Firecracker Plant. Scrophulariaceae. Native to Mexico.

Commonly grown in the tropics, this red-flowered shrub with arching green stems is well known to children in the area. The tightly adhering lobes of the corolla overlap. The flower may be 1 inch long and ¼ inch in diameter. When pressed between the fingers, the unopened flowers explode as a gentle firecracker. The specific name suggests a similarity in the appearance of the green-angled stems to those of the horsetails. While broad ovate leaves are developed, these last but a short time and the stem with chlorophyll manufactures most of the food for the plant.

***Penstemon* spp.** Scrophulariaceae. Native to western N. America.

Chelone glabra. Turtlehead. Scrophulariaceae. Native to eastern N. America.

Digitalis purpurea. Foxglove. Scrophulariaceae. Native to western Europe.

These additional members of the Figwort Family have elongated tubular corollas that are swollen in development. The overlapping petals adhere tightly and the corolla may become turgid and rupture when pressed.

Calyx Inflated in Flower or in Fruit

Physalis alkekengi. Chinese Lantern Plant. Solanaceae. Native to Europe and Asia.

The Chinese Lantern Plant is the most familiar ornamental species of this large genus and the best known example of an inflated calyx. The flowers are pendant and the calyx in this species is orange-red to bright red, angular in cross section, and extended to sharp calyx tips. The stems are picked and dried and commonly used as dried bouquets. A tomato-like red fruit is enclosed in the enlarged calyx and can be seen only if the calyx is torn deliberately. Unfortunately, this plant spreads easily by runner and can become a persistent weed in a garden.

Other species of *Physalis* are native or introduced in the United States and have smaller calyces that are swollen, but of a tan or straw color when dry. Several species are grown for the edible berries, the most common ones being known as the Cape-gooseberry, Tomatillo, Husk-tomato, or Strawberry tomato. The fruits can be removed from the swollen husk and eaten out of hand or used to make a preserve. Many grow and produce prolifically so that the ground can be covered below the plant with the fruiting calyx and its enclosed berries. These plants also spread by runners or persist from seed for

Physalis alkekengi. *a. Habit; b . whole fruiting calyx; c. section of calyx and berry.* Sterculia *sp. d. Open mature fruits showing marginal seeds.* Asclepias fruticosa. *e. Inflated fruit with soft spines.* Cardiospermum halicacabum. *f. Habit; g. single fruit; h. fruit walls have fallen showing spherical seeds. Drawing: Robin S. Lefberg.*

many years after initial cultivation and subsequent attempts at eradication.

Hernandia sonora. Hernandiaceae. Native to tropical America.

This and several related species occur in similar river bank habitats in the Caribbean, tropical America and tropical Asia. They can be cultivated as handsome, intriguing shade trees, for the leaves of young plants are very different from the foliage on older specimens. The leaves in some species are peltate to varying degrees and the flowers, generally unisexual, are borne in the same inflorescence or on different trees. The stamens have a flap type of dehiscence similar to that found in the Laurel Family and in some barberries. After the pistillate flower has been fertilized, the receptacle develops into a yellow colored cuplike structure that surrounds the fruit but is clearly separated from it by an air space. At the beginning of fruit development, the circular orifice of the cupule is adherent to the turbinate apex of the fruit and inflates, forming a balloon-like unit. On full maturity of the fruit, the cupule is free at the apex but attached to the fruit at its base. The fruit and its round cupule will roll a considerable distance downhill from the parent plant, or may be blown in a strong wind about the ground under a cultivated tree. If the fruit and cupule should fall into water, the unit bobs freely near the surface, open end up, and again may be carried a considerable distance. Eventually the cupule rots away or is eaten, leaving the fruit as drift material on sandy beaches. This is common in the West Indies and in Florida, and one specimen has been found on a Cape Cod beach in Massachusetts. The one-seeded fruits with ruminated cotyledons are crownlike at the apex, have rounded ridges on the side, and are strung as beads in seed necklaces in the West Indies.

Inflated or Swollen Fruits

The common garden pea is an example of the many inflated fruits found in genera of the Leguminosae. Pea pods, swollen and turgid, will pop if fresh when pressed between the fingers, due in part to the pressure of gas enclosed in the air-tight pod. Normally, of course, the pod is split to extract the green peas used as vegetables, but ripe pea pods float easily—perhaps as their normal means of distribution. Wild species of *Astragalus* in western North America produce inflated pods and have been observed rolling across desert sands through wind action. Among the garden ornamentals of the Pea Family are *Baptisia tinctoria, Colutea arborescens, Crotalaria* spp., and *Swainsona galegifolia*, all with conspicuously swollen pods.

Baptisia tinctoria. Wild Indigo. Leguminosae. Native to N. America.

This native perennial herb was cultivated extensively not many years ago and persists in old garden plots or near old foundations.

The foliage turns blue-black on drying and was used to produce an indigo-like dye. The flowers may be white, yellow or blue, and develop into inflated globose pods containing many small seeds. Fruit clusters are often used in dried arrangements.

Colutea arborescens. Bladder Senna. Leguminosae. Native from the Mediterranean region to the Himalayas.

Colutea is generally a shrub but may become a woody plant 15 feet tall. Dwarf varieties have been selected for garden use. The fairly large and attractive flowers vary from bright yellow to deep orange or a reddish color. The swollen fruits are elongated, 2 to 3 inches in length, and a pale cream color. The species is hardy in the Boston area and, although little used, is recommended for shrub borders.

***Crotalaria* spp.** Rattle-box. Leguminosae. Native and introduced from tropical areas.

A large genus of herbs and shrubs with foliage varying from simple to palmately compound leaves. The flowers may be blue, purplish, yellow or brown and can be followed by elongated racemes of inflated, elongated pods. When fully ripe the seeds tend to break loose and are free in the dried pods. The common name of Rattle-box is derived from the noise heard when the wind blows the pods. I have seen children in the tropics use clusters of these pods as maraccas. The tropical species can be grown as annuals in northern gardens and will flower in greenhouses. The plants are attractive in flower and the fruits useful in dried arrangements. Some enterprising seedsman should make these more readily available.

Swainsona galegifolia. Leguminosae. Native to Australia.

A genus of herbs or subshrubs grown in greenhouses or in warmer areas out-of-doors. *Swainsona galegifolia*, with deep red flowers, is the most commonly encountered species: others have blue-violet or white flowers. The pod in most species is turgid and inflated.

Inflated fruits are found in many other families of plants and occur on growth forms ranging from herbs to vines or trees.

Koelreuteria paniculata. Goldenrain-tree. Sapindaceae. Native to E. Asia.

The Goldenrain-tree is becoming a popular ornamental throughout the United States, and a number of cultivars now have been selected. It is useful as a shade tree and attractive through its bipinnately compound leaves with serrate margins. The trees flower in midsummer with conspicuous, large, bright yellow or golden-yellow panicles which show spots of red on close examination. The fruit is a large, bladdery, inflated, three-angled capsule produced in large numbers and remaining on the tree for long periods of time. The capsules are light and papery, rattle in the wind, and change color as they mature, becoming

Colutea orientalis. *a. Habit showing fruit; b. flowers; c. longitudinal section of fruit; d. cross section of fruit.*

Koelreuteria paniculata. *a. Leaf; b. fruits; c. cross section of fruit; d. single bract of fruit.*

a chestnut-brown color on many plants. Fully fruited panicles are spectacular in large scale dried arrangements.

Bixa orellana. Annatto. Bixaceae. Native to S. America.

The *Bixa* is a truly handsome shrub or small tree with many points of interest. The heart-shaped leaves may have bright red petioles and veins, and change position during the daylight hours, drooping at night. The flowers are borne in panicles and the petals are a soft pink or rose color with clusters of stamens with bright red anthers. The fruit is heart-shaped in outline, a vivid red color when mature and fresh. Swollen and "popable," it is covered with soft spinose protuberances and dries dark red-brown. The seeds are borne along the walls of the fruit and when immature are soft and a pink-purplish color. When crushed they produce a vivid orange-red pigment. Fully matured or dried seeds are dark red in color and when boiled or powdered are the "annatto" used today to color rice for Latin-American cuisine. In South America the Indians have traditionally used the pigment to produce ornamental patterns on the skin, and more recently the pigment has been incorporated in some "natural product" lipsticks. Older Americans will remember coloring margarine with a capsule that contained this pigment. Dried seeds of annatto or the powdered seeds are available in nature food stores or in Latin-American markets. *Bixa* may be grown out-of-doors in the south but has a role in greenhouse collections in the north. Small plants are attractive for their foliage, but will also flower and produce fruit. The inflated capsules are highly prized for flower arrangements.

Kleinhovia hospita. Guest Tree. Sterculiaceae. Native to tropical Asia.

Although this plant is not well known and is rarely cited, it is a handsome tree cultivated in warm areas of Florida and Hawaii. When in bloom with its abundant but small flowers, the tree appears to be covered with a gauze of pink. The fruits are angular, papery, inflated capsules with small seeds.

Kleinhovia contrasts with species of *Sterculia* of the same Cocoa Family. Plants of *Sterculia* may be stout-trunked large trees with simple or palmately compound leaves and comparatively inconspicuous flowers, often with a foul odor. One of the best known species has the appropriate scientific name of *Sterculia foetida.* In fruit, however, most of the Sterculias are spectacular. The flowers basically have five carpels, one to all five of which may expand into stalked, elongated, or globose "fruits" that are often brightly colored outside, or inside, or both. The woody or rigid walls of the fruits are expanded, if not inflated, with a conspicuous air space inside. When the fruits open, the colored seeds, small in comparison to most of the fruits that produce them, are borne on the edges of the fruit. They are commonly black or purple and contrast with the brightly colored

inner wall of the fruit which is often velvety in appearance. Caution must be used in touching the inner surface of all *Sterculia* fruits, for the soft appearance may be created by a myriad of sharp pointed needle-like hairs. Nevertheless, the mature open fruits with seeds are always prize winners in contests of floral or fruit arrangement.

Cardiospermum halicacabum. Balloon Vine. Sapindaceae. Native to tropical regions.

The original home of this slender herbaceous vine is unknown. The plant has been cultivated as an ornamental for many years, and has become established in many areas of the United States and generally in the tropics. The delicate slender stems with dissected, usually three-parted, leaves climb by tendrils developed from parts of the inflorescence of white flowers. The fruits are papery, inflated and three-angled. Enclosed in each section of the three-parted capsule are one or more black-purplish spherical seeds that sometimes appear silvery due to a minute shiny pubescence. Outer segments of the fruit may fall off, leaving the colored seeds attached to the papery, membranous, white "bracts." The plant can be grown as an annual in the north, or used as an attractive house plant in a pot with a small trellis. When in full fruit the plant lives up to its name of Balloon Vine, being heavily laden with fruit.

Herissantia crispa. Malvaceae. Native to tropical regions.

Although lacking a common name, this plant has an abundance of scientific names. It has been classified in the genera *Sida, Abutilon, Gayoides, Bogenhardia*, and, currently, *Herissantia*. It is probably a native of tropical America, but it is now found throughout the tropical areas of the world. *Herissantia* is an annual semi-woody herb with slender trailing or spreading branches. The plant can be trained on a trellis to form an attractive house plant. The soft cordate leaves are velvety in appearance due to a fine pubescence. Petals of the small flowers vary in color, but are usually white at the apex, and yellow, orange, or green at the base. The fruit consists of about twelve inflated, papery, one-seeded capsules arranged in a whorl and long lasting when dried.

***Staphylea* spp.** Bladdernut. Staphyleaceae.

Four species of the Bladdernut are common in cultivation. *Staphylea trifolia* is a native of eastern United States; *S. pinnata* is from Europe; *S. colchica*, from the Caucasus area; and *S. bumalda*, from Japan. The plants form shrubs or small trees with leaves having three or five to seven leaflets in a pinnate arrangement. The short terminal racemes of white or greenish-white flowers are aromatic. The fruits are papery and inflated, greenish or yellow in color, and usually open at the apex. All species are hardy in northeastern United States and are grown both for the flowers and the attractive lantern-like fruits.

Staphylea elegans *var.* Hessei. *a. Habit showing fruit; b. cross section of fruit; c. longitudinal section of fruit.* Staphylea Bumalda. *d. Fruit; e. cross section of fruit; f. longitudinal section of fruit.* Staphylea colchica *f.* grandiflora. *g. Fruit; h. longitudinal section of fruit; i. cross section of fruit.*

Merremia tuberosa. Wood-rose. Convolvulaceae. Native to tropical America.

The common name applies to the fruits of this robust vine, which are well known for their use as corsage components or in dried arrangements. The light-colored, rigid but papery calyx enlarges in fruit, and surrounds an inflated capsule that is papery, dark or chestnut-brown in color. This contains free, large, angular seeds. Although seeds are often offered and suggested for culture as house plants, this vine has value as such only for the divided leaves. In tropical areas it quickly covers and obscures a fence, or it climbs to the tops of tall trees before displaying the bright yellow flowers and developing fruit.

Asclepias fruticosa (*A. physocarpus*). Milkweed. Asclepiadaceae. Native to Africa.

Although commonly cultivated in gardens in Europe, this plant is rarely seen in American gardens. The slightly woody stems may reach a height of 3 to 6 feet as an annual. The typical milkweed flowers are small and pink in color but develop an inflated fruit the size of a tennis ball or larger. Soft threadlike protuberances cover the surface of the green to light yellow or white fruit. The inflated portion consists of a spongy mass of tissue outside of the harder inner unit which contains the seeds.

Calotropis procera. Crown-flower or Dumb Cotton. Asclepiadaceae. Native to tropical Asia.

The pink, purple and white flowers of this tropical shrub or small tree are used in Hawaii for making the Crown-flower lei. In tropical America the plant is reputed to have medicinal properties. In either case, it is well to keep in mind that the copious milky sap may be caustic to sensitive skin. The fruit may be single or borne in pairs, and is inflated below the skin by spongy, cotton-like tissue. Large fruits may be 6 inches in diameter. The sessile gray-green leaves give the plant a characteristic appearance and allow easy recognition of it in drier areas of tropical America.

These are but a few of the inflated fruits or flowers one may encounter in the flora of the world. In the many ways plants have evolved and developed specialized means of distribution, the inflated fruit remains unusual. The characteristic, however, does make such plants attractive as ornamental occupants of a selected spot in your garden or greenhouse.

Transplanting Stress - A View from the Plant's Perspective

by Gary L. Koller

Transplanting, a horticultural process as old as civilization, is generally misunderstood and often results in the loss of many beautiful or valuable plants. This is due in part to the fact that many people disregard the living aspect of the plant and treat it as they would a piece of furniture. Even under the most optimum conditions, the first year is full of great hazards for the newly transplanted specimen. Some of the problems it may encounter and some guidelines are discussed below.

Root Loss

Roots are part of the life support system of the plant and function in the uptake of water and minerals, while providing anchorage and support for tall growing woody specimens. During transplanting the components of this vital system often are brutally hacked, mangled, and reduced so that little remains except thick, woody segments shorn of the tiny, actively growing root hairs essential to moisture and nutrient absorption. Since these root hairs also secrete substances aiding the movement of the root into new soil areas, their regeneration is extremely important. Anything that slows this recovery retards the ultimate growth of the plant.

Minute fungus organisms collectively called mycorrhiza often live in association with the root hairs and assist with water and mineral uptake, possibly even synthesizing materials beneficial to the larger host. This symbiotic relationship is not well understood, but may affect the success of a plant in its new location. It is believed that many plants known for transplant difficulty are lost because the proper soil organisms are lacking.

Old horticultural literature often suggests that soil from the old planting location be incorporated into the soil of the new; this would inoculate these microorganisms into the new site. The new soil should be favorable in terms of composition, aeration, pH, and moisture to encourage the fungus to grow and thrive. At present the state of horticultural science has not provided techniques that we can adapt to our home plantings to increase success associated with the microorganisms.

An abandoned plant from which the container has rotted away. Note that the tree rooted through the bottom. With time, erosion may wash the soil from the root ball and leave the upper surface exposed and vulnerable to mechanical damage. Photo: G. Koller.

Wilting

The root system, even in the best transplant operation, is greatly reduced; on woody plants this loss must be compensated for by removing at least one-third of the growing vegetative shoots. Neglecting this essential step intensifies the following plant reactions: Preformed vegetative buds, based on the strength and vigor of the plant prior to moving, burst into growth. The plant immediately undergoes moisture stress because there are not enough roots to support the lush growth.

Generally a wilting plant is watered immediately and until the wilt symptoms disappear. What is not obvious is that this wilting causes internal physiological tissue stress that upsets the normal chemical activities of the plant. After a severe moisture stress it may take weeks for the chemical and hormonal balance to readjust so that normal growth may be resumed.

During the normal drought of late summer, newly moved plants generally undergo several periods of wilt and each subsequent occurrence requires a longer period of recovery. As a result of the chemical slowdown, fewer carbohydrates or food are elaborated in the foliage and less material is transported downward to support the growth of a healthy root system. The longer the root is deprived of its full potential food supply, the longer it takes for complete recovery.

Initial damage from lack of water is very insidious and the chemical reactions may slow down before the plant goes limp and droops; therefore it becomes important to supply additional water on a regular basis throughout the first full growing season and beyond depending on rainfall, soil conditions and vigor of the plant. Even if specimens seem to have recovered, the heat and drought of late summer necessitate this precaution.

Insects and Diseases

During the process of transplanting, many plant roots and branches may be cut or broken, creating wounds that allow the entry of disease organisms. In its new site the plant may undergo severe stress from the wind, reflected heat, and inadequate soil moisture. In such a weakened condition, it is particularly prone to the attack of insects as well. The quicker the specimen recovers and resumes full growth, the less likely the chance of these invasions.

Timing the Move

Bad timing seems to be the most frequent error the home owner makes in moving existing plants from one location to another. Most amateurs assume that the plant needs to be in leaf, but the stresses on the root system that are imposed by the lush foliage lessen the plant's chance of survival.

Plants that have been growing in naturally existing soil are most successfully moved when they are in a dormant or quiescent state. In north temperate areas this can occur at two seasons. The first begins any time after spring soil thaw and lasts until the plant begins active vegetative growth (the best rule is "the sooner the better").

The reason for transplanting as soon as the soil can be worked is that the plant produces the most active root growth when soil and air temperatures are low, and before vegetative growth begins. Research indicates that once top growth commences, root growth slows and in some cases halts. Early transplanting will allow maximum root growth to supply necessary water to unfolding leaves, stems and flowers.

The second transplanting season begins in late summer after all vegetative portions have expanded and the tissue has hardened off, therefore requiring less water. Fall transplanting may be most advantageous for those plants considered to be reliably hardy because it will permit active root growth in late fall and again in early spring before new vegetative growth begins. In the autumn it is considered optimum to await frost and defoliation of most deciduous plants. However, in northern areas where weather is severe and deep soil penetration of frost may damage semi-anchored plants, early transplanting prior to defoliation may be preferable.

At the Arnold Arboretum we begin moving needled evergreens in early September and try to accomplish this task before the latter part of October. During late October the first killing frost generally occurs, bringing active vegetative growth to a halt. As the soil and air temperatures go down, active root growth begins again and allows some degree of anchorage before frost penetrates the soil deeply. Additional root growing time can be achieved with the use of a thick basal mulch around the plants.

In northern areas with low winter temperatures and sweeping winds some plants should not be transplanted in fall. This group includes all broadleaved evergreens, any plant that is considered to be marginally hardy, and young, poorly rooted specimens.

Cold sweeping winds can dry out the evergreens which, even under ideal conditions, have problems with water uptake from frozen soils. Plants of marginal hardiness are prone to freezing; spring transplanting permits them to have a whole growing season to store carbohydrates for increasing winter hardiness. This additional growing time also benefits semi-anchored plants by allowing them to root fully.

The nursery industry has increased the planting season by growing plants in large containers or digging them with a soil ball and wrapping the soil with burlap. As a result it is now possible to install plants at any time during the growing season, but these modern methods have not reduced the need for good follow-up care.

The nursery industry is now digging trees and shrubs bare-root and potting them for an extended sales period. Occasionally a poor root system results, as in this young pine tree. Prior to purchase it is advisable to carefully remove a plant from its container and check along the sides and bottom of the root ball for adequate development. Photo: P. Chvany.

Most large trees are moved with a firm soil ball which reduces root disturbance, retains moisture from irrigation water, and increases transplant success. Photo: P. Chvany.

Soil Conditions

In the past most nursery plants were grown in natural soil occurring at the nursery site, then they were transferred to natural soil at the customer's house. Generally the soil was prepared to receive the plant by the addition of organic matter and drainage material, using some magical formula as a guide. What usually resulted was a soil aggregate that packed together like cement.

Soil preparation is essential and deserves careful attention. If the existing soil is well drained, it usually is not necessary to add drainage material. A large hole should be dug to loosen the soil and reduce compaction, thereby improving soil structure. In most instances it is advantageous to reuse the excavated soil as return fill. Before doing so, however, the soil should be amended with an equal volume or more of organic matter in the form of compost, leaf mold, wood chips, etc. It is scarcely possible to add too much. The organic matter loosens the soil particles, traps and stores water, and becomes the sponge that captures fertilizer and holds it for long term use by the plant. Because these functions contribute to quick root regeneration, the plant re-establishes more readily.

The soil should be firmly pressed around the plant's roots. Some of the excess may be used to form a saucer around the base of the plant so that water will soak into the proper area.

In many soils drainage is a problem and it becomes necessary to add sand, gravel or drainage pipes to allow for the movement of excess water. In amending the soil, enough coarse drainage material must be added to separate the fine textured soil particles that tend to pack together. Equally important is the incorporation of large quantities of organic matter.

Where drainage is a severe problem, it may be easiest to garden above ground level by using modified, well-drained soil to create mounds or raised beds. This permits free water to drain to the existing grade and away from the critical root zone.

A new soil problem has recently entered the picture. For some time nurseries have been using a lightweight, highly modified soil mix supplemented with time-released fertilizers as well as periodic applications of liquid or granular fertilizer. Plants are grown with supplemental light and watered very efficiently — a cultural combination that gives quick growth, develops good root systems, and produces saleable products in the shortest amount of time.

The trouble occurs when a lush, vigorous plant gets to the customer's yard where it is put into an inferior soil, is lucky to get any fertilizer, and is watered only when it displays severe wilt symptoms. I don't propose that the nursery industry change its growing methods, but we do need to look at what can be done to better assist the transplant at its new site.

This plant is well staked and its trunk is wrapped to prevent sun scald. But the planting demonstrates two major errors: The top of the tree was not pruned; a shallow saucer of soil to hold irrigation water was not provided. Photo: P. Chvany.

In preparation for planting, outer roots of a containerized pine seedling have been gently pulled away from the root mass so they can draw moisture from the larger volume of new soil. This procedure also helps the roots to make the transition from the artificial soil mix to the natural medium. Photo: P. Chvany.

It has been found that plants raised in light soil mixes have great difficulty growing roots into the existing soil substrate at the planting location. While some of the reasons for this are unknown, it may result from varying moisture conditions between the soil mix and the surrounding soil, or the creation of soil interface problems.

The artificial soil mix will hold a great quantity of water, but when it becomes totally dry it is difficult to rewet. When a plant is installed in a permanent location, it is usually set at the same depth as it was in the container so that the upper surface of the light soil mix is exposed to the air. A wick-like effect occurs and the artificial soil dries out much faster than the surrounding natural or amended soil. This creates a moisture stress in the soil mix and it may also shrink, causing a gap between the containerized root mass and the surrounding prepared soil.

To prevent this problem, check for root development after lifting the plant from its container, and eliminate all surplus soil mix in the area where there are few or no roots, using your finger or a mechanical device. If possible, loosen roots so that they can be pulled away from the mass. During this process the roots should not be allowed to dry out and a bucket of water should be kept handy for moistening the root ball. A portion of the topsoil also should be scraped away; this will be replaced with soil from the planting site after the plant is reset at its original depth. In planting, care should be taken to spread the loosened roots into the backfill.

Pruning

Pruning is essential to the transplant operation. People are usually hesitant to reduce the size of an expensive plant because they want an instant effect. As a result, they jeopardize the long term survival and health of the plant . The minimum that should be removed is generally considered to be one-third of the growing stems. This reduction accomplishes the following goals: It reduces moisture stress; invigorates the plant and directs more energy into fewer growing points, while stimulating the development of adventitious buds; provides the opportunity to shape and control growth by removing interfering or rubbing branches, dead wood, and lush vegetative growth. As a rule, the pruning should not be in the form of a crew cut which shears all stems back to the same level, but rather a selective thinning.

Equally important to top pruning is root pruning. Removing damaged and broken roots and making clean cuts on ragged edges encourages new growth to cover and protect these sensitive areas that are in intimate contact with soil-borne disease organisms. Root pruning also tends to make roots branch, which is especially critical in the success of tap-rooted plants such as oak, hickory and sassafras.

Staking

One factor that tends to retard root growth is lack of proper support. A newly planted tree or large shrub has a foliage mass that catches the wind and acts like a sail. In addition, the height of tall plants causes an instability due to imbalance. As the wind blows, these plants shift back and forth causing actual movement of the soil ball within the surrounding prepared soil area which is soft and porous. This slow movement and friction tears away minute but critical root hairs, slowing the recovery of the plant. To reduce the amount of sway, all large plants should be securely staked, but the binding should be loose enough so it will not girdle the stem.

Prolonged staking tends to weaken the stem and may lead to top-heavy plants. Normally, a windblown or windstressed tree develops additional wood fiber or support roots to offset or compensate for the stress. With rigid and prolonged staking this natural process is retarded and structural weakness may result. Consequently, it is important to stake the plant during its first full year to encourage the most rapid development; after that time it is equally important to remove the support.

Planting Depth

Most plants have adapted their root growth to soil levels most conducive to maximum growth. After transplanting, the prepared soil becomes compacted and the heavy plants settle down to a depth greater than that to which they were accustomed.

From observation it seems that a plant will adapt more quickly to slightly shallow planting rather than to being set too deeply. The only problem that may result from shallow planting is that the plant may be top-heavy and blow over. To prevent this, initial support or staking becomes critical so that the plant can sink new support roots.

Fertilization

Many people insist on fertilizing a newly planted specimen by applying chemicals to the bottom of the planting hole or mixing the material with the backfill. Often this causes more harm than good, for the chemicals easily burn or dehydrate sensitive young roots.

During the first growing season the plant may be assisted with an occasional application of a liquid or soluble fertilizer applied with the irrigation water. If the soil is extremely dry it should be well watered before the liquid fertilizer is applied.

Once the plant has been in place for a year and is somewhat established, it will benefit by supplemental granular fertilizer applied every second or third year to stimulate vigorous and healthy growth.

Woody plants frequently are selected on the basis of their rapid growth and quick effect, but the owner subsequently provides no support for this vigorous growth in the form of supplemental nutrition. Slow growing trees and shrubs, generally the most successful over time, can be hastened into growth with periodic fertilization and in many instances will out-perform those rapid growing, unfertilized plants.

If commercial agriculturists operated without catering to the nutritional needs and water requirements of their crops, we would be unable to feed the present world population. Most ornamental plants struggle along on their own and are blamed if they perform poorly; more often it is we who are at fault. As their guardians we must attend to their needs so they will thrive and produce the lush growth that cools, and the brilliant flowers that brighten our world.

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Girdling Roots

by Kenneth Shaw

A problem now becoming apparent in many plantings and one that will be even more serious in the future is that of constricting and girdling roots. Girdling develops when the normal course of a root is deflected by a barrier, or when an unfavorable interface exists between the transplant's medium and the soil type at the planting site. A hyperplastic symptom termed sarcody, which is an abnormal swelling above or below a constricted organ, can be caused by girdling roots. When a root encircles the trunk above the soil's surface, the swelling usually occurs above the girdled area (Fig. 1 and 2). This type of damage is easily detected and corrected by cutting the girdling root cleanly, and dressing the exposed wounds with a tree paint.

In other cases, the restricting root may be forced out of the way by the swelling of the main roots (Fig. 3), or the tree may grow over the offending roots (Fig. 4). Occasionally, the entwining surface roots may be normal and require no corrective treatment (Fig. 5).

When a root encircles the main or tap root below the soil surface, the normal flaring of the trunk at ground level is checked; instead, the tree trunk rises straight up with no flare at the base. Girdling roots in this area can cause many problems. Plants become weak and have reduced vegetative growth due to restricted translocation of nutrients and water. Leaves are smaller, having a tendency to show nutrient deficiency symptoms and wilting during dry weather. Fruits are smaller and abscission is premature. The stability of the plant also may be affected.

Instability is often noted shortly after planting, as soon as the wind has had a chance to blow the plant around, and results from binding of the buttress roots by an encircling root (Fig. 6) so that support begins lower than normal. Thus, top-heavy plants sway back and forth, pushing the soil away from the tree base and forming air pockets. This type of air pocket and those present around twisted, encircled roots provide an excellent microclimate for pest organisms, a condition that should not be encouraged.

Container-grown plants probably offer the best example of girdling caused by deflection from a barrier, although the condition also is seen in street trees planted in compacted soil between the sidewalk and the road, and in forest trees growing over a hardpan.

Above: Fig. 1. Girdling of an ash's buttress root.
Below: Fig. 2. Surface roots encircling a maple tree. Photos: K. Shaw.

Containerized plants have become very popular because they are easy to handle, extend the planting season, and reduce root loss at transplanting time. The last is important with plants like magnolias, dogwoods, and cytisus which have fragile, fleshy root systems easily damaged by balling and burlapping.

Girdling roots may also develop on bare-rooted transplants that have been crammed into a small hole, which results in twisted and circling roots. The proper method of handling plants is to dig a hole large enough to accommodate all roots after they have been straightened.

The composition of the transplant's medium and the soil at the planting site is usually dissimilar. When a plant is merely slipped into a hole, with no melding of the soils, an abrupt soil interface is created. At transplanting time the two soils should be blended together, so that no drastic change occurs from one type to the other.

Left above: Fig. 3. Surface root approaching a maple trunk; notice swelling over restricted portion.
Below: Fig. 4. This maple tree has overcome a restricting surface root.
Above: Fig. 5. Entwining surface roots of an American beech. Photos: K. Shaw.

The abrupt soil interface mainly affects the oxygen and water holding capacity of the soil, which has a primary influence on the developing roots.

A soil interface problem is created when planting is done in moist clay soils. As the shovel cuts through the clay it slicks the sides of the hole, thus creating an impenetrable surface similar to that of a container. This condition can be remedied by scratching the hole's surface before planting.

Grafted plants may suffer from being containerized because it is likely that the root stock was grown in a container for a year prior to grafting. When buying such plants, check to see if the plant material is pot bound; if it is, don't purchase the plant unless there is no alternative.

Fig. 6. Pyracantha with support roots bound together by a girdling root that has sent up a shoot of its own. Photo: K. Shaw.

If the encircling roots are not noticed until transplanting time, you may be able to exchange the plant at the place of purchase, or you can remedy the situation yourself. This is done in a shaded area to protect the roots from direct sunlight ("a minute in sun and the root's done"). The plant should be watered first so that the soil ball will hold together after removal from the pot. The spiralling roots can easily be stretched out and cut off (Fig. 7). Dense clusters or mats of entwining roots (Fig. 8) that occupy nearly all the soil mass can be handled by making three slices spaced equally around the soil ball to cut any looping or encircling roots that may cause girdling later. The plant is now under stress and needs after-planting care, which involves shading for at least two weeks, and keeping the plant watered well the first season.

Left: Fig. 7. Spiralling roots of a containerized seedling pine.
Right: Fig. 8. Shallow cuts are made through dense outer root mass to sever encircling roots. Photos: P. Chvany.

Horticultural Trainees Program

by Margo W. Reynolds

For a number of years, the Arnold Arboretum has supplemented its ground maintenance staff in the summer with college students interested in botanical and horticultural careers who wished practical experience. Students have had the opportunity to work alongside veteran members of the grounds crew, learning the mechanics and techniques necessary to maintain and improve the living collection. A weekly rotation of duties exposed them to as many different maintenance jobs as was possible within the space of a summer. Fertilizing, spraying, pruning, weeding, mulching and transplanting have been but a few of the duties assigned. A week on the pick-up truck collecting trash has been considered a rite of passage for all; unglamorous though it is, it points out quite graphically that litter (and its effective control) are major problems in many arboreta that are heavily used by the public.

A series of Friday morning lecture/field trips soon became part of the program. Various staff members introduced facets of the Arboretum's diversified activities, such as the research facilities in Cambridge, the collections at the Case Estates, the herbarium, the educational programs, the Friends, and the Arboretum's publications. Field trips were taken to Mt. Auburn Cemetery, the Hunnewell Estate, the Suburban Experiment Station in Waltham, and the Franklin Park Zoo as well, to acquaint the students with other horticultural resources in the Greater Boston area. In 1975, these summer students were officially designated "horticultural trainees."

Evaluation forms distributed to the students at the close of the 1976 summer session were encouragingly candid and characterized by a certain amount of constructive criticism. It was particularly heartening to see the care with which many of the trainees filled out the evaluations. Oftentimes, where merely a √ would do, students took the time to write lengthy explanatory remarks and comments.

As a result of last summer's questionnaires, the goals and content of the existing program were re-examined and evaluated. Under the supervision of Drs. Spongberg and Weaver, the staff worked throughout the past year to produce an academically-oriented program that

Second-year horticultural trainee Caroline Kehne learns Arboretum library procedures. Photo: M. Reynolds.

would more realistically serve the needs of the students, nearly all of whom plan careers in botany and horticulture. As a result, this year's summer program represented a change in format and content, adding a new dimension to the horticultural trainees' preparation.

The program has continued to give students the practical experience in grounds maintenance work considered so valuable by future employers. In addition, students have met for four hours each Wednesday morning as participants in an academic course entitled "Botanical and Horticultural Practices at Arboreta." Upon successful completion of the course, each trainee will receive four college credits through the Harvard University Commission on Extension Studies.

The course was designed to relate the botanical and horticultural knowledge of the students to its practical application in arboreta and botanical gardens. Topics considered included the principles of taxonomy and the classification of vascular plants, as well as special problems presented by plants in cultivation. A special section on woody ornamental plants in the landscape emphasized the application of botanical and ecological theory to the use of plants in the environment. The development and maintenance of living collections stressed horticultural practices and equipment.

As part of the course work, each student was expected to select, with instructor guidance, a research project to be conducted during the ten-week term. A written report on the investigation was required at the course's conclusion. Among areas of student interest this summer were a phenological study of flowering in certain deciduous trees, studies of the genera *Indigofera* and *Physocarpus*, and a project on economic entomology. A number of students worked on the development of interpretive labels for various of our collections; still others studied weed identification, and edible trees and shrubs. For all, staff and students alike, it has proved to be an educational summer.

Student Jerald Shing tackles the pruning of an overgrown juniper. Photo: M. Reynolds.

The Room of Delight. Oldrich Otypka. Cranbury, N.J.: A. S. Barnes and Co. Inc. 164 pages, illustrated. $15.00.

A Minnesota designer of heating and air-conditioning systems and a plant lover, Mr. Otypka describes in this book the fulfillment of his long-held dream for a garden in his home. Most of the text is devoted to a description of the plants suitable for an indoor garden and the details of their culture. The author's own photographs, some more effective than others, and some in color, illustrate several of the plants. An excellent section of plants that may be wick-watered, and lists of plants that are insect-free, sources for plants and greenhouse structures and allied equipment are also included.

Regrettably, the details of the room itself and its requirements cover a scant dozen pages. Even the photographs of the author's room of delight do not give a clear idea of its extent and plan.

B. June Hutchinson

E. I. du Pont, *Botaniste*. Norman B. Wilkinson. Charlottesville: The University Press of Virginia. 139 pages, illustrated. $7.50 hardcover; $3.95 paperback.

The du Pont family was of great horticultural significance in American gardening history and the gardens of Longwood, Winterthur and Eleutherian Mills are a testament to their interest in horticulture and garden design. This work is an historical and anecdotal biography of Eleuthère Irénée du Pont, a French ancestor of these American du Ponts and the man who laid the family's horticultural foundations.

A boyhood interest in gardening in his native France became a consuming interest throughout E. I. du Pont's adulthood in America. Strong ties with his homeland resulted in shipments of numerous seeds of American trees and shrubs to France. His strong horticultural leadership affected successive generations of the family and resulted in the establishment of the famous gardens with which many of us are familiar.

The author is Director of Research for one of the du Pont foundations and his account is interesting, albeit a bit worshipful. He has constructed his story from family memorabilia, anecdotal accounts, letters, and other documents. Parts of it are fascinating reading, as when we discover that in addition to sending seeds of such American favorites as sourwood, sweetgum, wintergreen and mayflower to France, du Pont also sent prodigious quantities of poison ivy. Du Pont is portrayed as what we might now call an "apecatos" (operator) and his wheelings and dealings with the French upper class, and Josephine Bonaparte in particular, make enjoyable reading.

Visitors to any of the du Pont gardens will find value in this book, which is richly illustrated with fine quality photographs. This reviewer would have liked to have seen a geneology and a brief chronological history of the family included as well as a more coherent reader orientation in the first chapter, but these are small failings in an otherwise intriguing book.

Elinore B. Trowbridge

The Complete Garden. Arnold Leggett and Pat Falge. Willits, Calif.: Oliver Press. 246 pages, illustrated. $3.95, paperback.

This book is beyond my understanding so I quote the introduction to explain its purpose: It is "to provide sources for those seeds and tools which the homesteader may wish to use in bringing food from the earth." The book consists of two alphabetical indices. The Master Index lists the products, with the companies offering each item, and a company index supplies information about each company, including a list of available items.

The logic behind the idea is obvious, but not so obvious is the criteria used to select the companies to be listed in the book. Items such as environmental calendars and Hawaiian perfume, to name but two, do not seem relevant to bringing food from the earth. Also confusing is the fact that the Master Index lists different sources under Latin and common names of many plants. Thus, adjacent entries for Gentian and *Gentiana* have no common source.

Novice gardeners may find something of interest in *The Complete Garden* but those with experience will have better use for $3.95.

SHELIA MAGULLION

Wildflowers of Hong Kong. Beryl M. Walden and Shiu Ying Hu. Hong Kong: Sino-American Publishing Co. 83 pages plus 83 plates. U.S. $25.00. H.K. $125.00.

Paintings for this book were done from living specimens of 255 plants of Hong Kong; a few cultivated, a few adventive weeds, but mostly the wild flowers as trees, shrubs and vines. The plants are pictured as seen and are without leaves when appropriate, some insect eaten, some in flower or in fruit. The drawings and reproductions are excellent and the volume includes many plants not commonly illustrated. The textual material comprises scientific and common names in English and Chinese, ecological notes, brief descriptions and often economic uses. Entries are arranged by the month in which the material was collected, and reference is given to the plate or plates. Some plants are shown two or three times. Each figure is numbered and a numerical list is supplied, along with a bilingual glossary, an arrangement of plants according to the Engler system, and an index by page and plate.

This is an attractive volume and one needed for the plants of Hong Kong and the New Territories. It is not a field manual, however, and one hopes for a future paperback volume of smaller size. One wishes for an easier reference to the family for unfamiliar genera, also.

The dust jacket is truly a work of art and, with several of the plates which illustrate a single plant, should be made available for framing and individual use. The publisher has offered to supply copies autographed by the artist and the author if the order is placed through the Arnold Arboretum. However, this offer must be of limited duration.

RICHARD A. HOWARD

From Wild Flowers of Hong Kong.

ARNOLDIA *is a publication of the Arnold Arboretum of Harvard University, Jamaica Plain, Massachusetts, U.S.A.*

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Cover: Mrs. Sylvia Grey, a RSVP volunteer. Photo: P. Chvany.

The Director's Report

The Arnold Arboretum During the Fiscal Year Ended June 30, 1977

The dictionary definition of an arboretum as a place where trees and shrubs are cultivated for scientific or educational purposes is an inadequate description of the Arnold Arboretum today. While neither the largest nor the smallest of America's botanical gardens and arboreta, it is among the most active in the use of its collections for these purposes. The living collections have been designated a National Historic Landmark; and the herbarium, a National Scientific Resource. The use of the collections is not limited to the staff: the general public finds the Arnold Arboretum a pleasant place to visit, and it is a source of information for education, science and industry with the staff handling requests and visitors from many states and foreign countries.

The Arnold Arboretum functions in three areas: Jamaica Plain, Weston, and Cambridge, with staff members in each location. Most of the land in Jamaica Plain is owned by the City of Boston, and used by the Arboretum for a token rental fee on a long-term agreement. Since the Arboretum is considered a part of the Boston Department of Parks and Recreation, the City is supposed to maintain the roads, fences, and benches, and to offer police protection. The Arboretum staff and funds maintain the collections, with the agreement that they be open to the public at reasonable hours. The Arnold Arboretum is considered a charitable trust administered by Harvard University as a department. Neither the City of Boston nor Harvard contributes directly to the financing of its operation. Gifts and bequests from the public in the past have created an endowment, with the income and contributions from current Friends forming the operating budget. Accounting procedures and benefit programs are those of the University, and Arboretum funds are assessed for them. Staff members may have academic or nonacademic appointments, and the grounds staff is represented by a union. The complexity of these interrelationships is evident in many items of this report.

A grant from the National Science Foundation for the past three years has supported curatorial work in the herbarium and library in Cambridge. None of the money could be used for horticulture or for the care of the living collections. In an application for a renewal of this grant, information was requested and supplied on the number of professional visitors who used the herbarium or the library. Their

location in a closed building permitted the tabulation of use by means of a guest book with visitors' signatures. The living collections in Jamaica Plain are partially surrounded by a fence. However, the gates are not operable and the general regulations of being open sunrise to sunset cannot be enforced. With 265 acres and many gates, no accurate count of the visitors is possible. The Case Estates of the Arnold Arboretum in Weston are not fenced at all, and a visitor record is impossible to acquire. We have police department estimates of fifty to sixty thousand people in Jamaica Plain for a fine Sunday in May when the lilacs are in bloom. Parking of cars around the periphery of the Arboretum is a problem on such days. Although no reliable figures are available for the total number of visitors in the course of the year, it seems likely that sixty per cent of them visit the grounds during May when most of the shrubs are in flower.

With the aid of volunteers this spring, a questionnaire was compiled and visitors were interviewed to determine who they were, where they came from, and why they were here. A random sample of three hundred revealed fifty-one per cent female and forty-nine per cent male visitors, twenty-three per cent alone, thirty-three per cent with friends, thirty-nine per cent with family, and five per cent as part of an organized group. Daily visitors numbered ten per cent; twenty-five per cent came once or twice a week; twenty per cent, once a year. The largest age group was eighteen to thirty-four, representing fifty-five per cent of the visitors interviewed. Towns inside Route 128 produced sixty-four per cent of the visitors, with twenty-two per cent from Jamaica Plain and eighteen per cent from Boston. Visitors from out of the state were twenty per cent of the total and included some from twenty-four states besides Massachusetts. Newspaper publicity and radio or TV announcements accounted for only six per cent of the visitors. When asked about the labels, ninety-two per cent of the vistors responded that they looked for and read the labels on the plants. The information they found was useful to eighty-six per cent and only twenty-eight per cent wished for more information; yet forty per cent reported they came to the Arboretum, in part at least, to learn more about plants. Every visitor interviewed responded to a question concerning the problems at the Arboretum, which were listed in order: litter, vandalized labels and plants, dogs, bicycles, and skateboards. It is of interest to the staff that eighty per cent of the visitors indicated they would pay a nominal entrance fee to visit the grounds. Much of this information and additional items elicited by the questionnaire will be used in developing methods of operation and education programs.

Dr. Richard A. Howard presents gifts to Alfred J. Fordham at the latter's retirement party. Photo: M. Reynolds.

Staff

Several University departments and special committees were active during the year considering the larger problems of employment at Harvard. Arboretum staff members received questionnaires relating to their job classification and compensation. Recommendations received subsequently from the Personnel Office were implemented, with changes of job title, level of classification, and increases in salary rate.

June 30 marked the retirement of Mr. Alfred Fordham, who joined the staff on February 1, 1929 as assistant in the propagating department, and served for many years as the plant propagator for the Arnold Arboretum. As an expert propagator of plants for our collections, Al Fordham handled equally well a role as a lecturer, writer, and talented representative of the Arboretum to the horticultural profession. During the last year he was given the appointment of research horticulturist, with freedom to continue his writing, while being available to help his successor as needed. The staff expressed appreciation to Al in a cooperative retirement party attended by many of his friends.

Resignations were received from Dr. Kenneth Robertson of the Generic Flora of the Southeastern United States project, Miss Jackie Smith and Mrs. Marsha Knoll of the herbarium staff, Miss Rebecca Rohr, Miss Nancy Karasik and Mr. Patrick Pancoast from the library, and *Journal of the Arnold Arboretum* technical editor, Miss Kathleen Clagett. New employees included Miss Carolyn Hesterberg in the herbarium office, Miss Sandra McLeod and Mr. Mark Belson in the library, Miss Laura Frank providing secretarial assistance, Mr. Kenneth Shaw as assistant supervisor of the living collections, and Mrs. Elizabeth Schmidt as assistant editor of the *Journal*.

Dr. Peter Stevens received an academic appointment for three and a half years as assistant professor of biology in addition to his curatorial appointment. Dr. Stephen Spongberg and Dr. Richard Weaver were given appointments of unspecified duration as horticultural taxonomists at the Arnold Arboretum. Mrs. Ida Burch was reclassified as a staff assistant.

Dr. Bernice Schubert and Mr. Michael Canoso were recognized by the University in a special ceremony honoring those who had served the University for twenty-five years. Mr. Fordham was honored by the Massachusetts Horticultural Society with a Certificate of Appreciation. Dr. Richard Howard received a citation from the American Horticultural Society for services to that organization; he also was elected an honorary life member in the Garden Club Federation of Maine. At the commencement exercises of Framingham State College, Dr. Howard received an honorary Doctor of Science degree with the citation:

> "Scholar, interpreter of the world of plants to people of all ages, botanical explorer in the world's remote corners, entrusted with the care of our botanical treasures, he has taught us survival in the wilderness and the beauty of civilized nature."

Four committees have been functioning during the year to consider the problems of operation of the Arboretum. The horticultural committee meets weekly and has been chaired jointly by Dr. Weaver and Mr. Koller. All staff members in Jamaica Plain, including the superintendent and union representative, are invited to attend the discussions. The library committee, chaired by Mrs. Lenore Dickinson, librarian jointly for the Arnold Arboretum and Gray Herbarium, has as members Drs. Schubert and Spongberg of the Arboretum staff, and Dr. Elizabeth Shaw of the Gray Herbarium. Dr. Alan Erickson attends as Science Specialist in the Harvard University Library. The herbarium committee is chaired by Dr. Norton Miller, a joint appointee of the Arnold and the Gray Herbarium, and includes Mr. Canoso, also a joint appointee, Drs. Weaver and Wood of the Arnold, Dr. Rolla Tryon of the Gray Herbarium staff, and Dr. Donald Pfister, representing the Farlow Herbarium. The *Journal of the Arnold Arboretum* committee functions under the leadership of Dr. Schubert

with staff members Drs. Spongberg, Stevens and Wood; Mrs. Schmidt, the assistant editor, serving as secretary. An educational committee for Jamaica Plain comprises staff members Burch, Canoso, Koller and Mr. George Pride, volunteer Mrs. June Hutchinson, and Mrs. Margaret Savage representing the Neighborhood Coalition of Jamaica Plain. Miss Margo Reynolds serves as chairperson. Reports of the committee meetings are posted; and plans, programs, and recommendations are circulated in the staff-produced *Arboretum Newsletter* edited by Miss Reynolds. Through these media of communication, the staff is informed of the diverse activities of the three locations and the responsibilities of the staff members.

Horticulture

The care of the living collections and the appearance of the grounds are the responsibility of the Arboretum staff. However, by legal agreement almost a century old, the protection of the collections by fences and gates, the care of the roads, paths, and benches, and the surveillance by the police are the responsibility of the City of Boston. The care of the living collections is becoming increasingly difficult through the failure of the City to fulfill its obligations. In spite of meetings with City officials last year, there has been no improvement, and little cooperation beyond that of Station 13 of the Police Department. Fences in conspicuous locations, damaged by automobiles, remained unrepaired during the full year, although a section of stone wall was restored. The City asked for bids to repair the driving and pedestrian gates which are so deteriorated as to be unsightly, and the Arboretum staff cooperated in determining priorities. However, no contract was awarded and nothing was done. The macadem paths are so fractured in many areas that they are dangerous for pedestrians, and pieces are used regularly by vandals as missiles. Almost in desperation the director requested permission from the President and Fellows to spend Arboretum funds on a three-year program to repair those gates, fences, paths and benches which are the City's responsibility. A proposal, legally acceptable to the University, and one which would protect the Arboretum, was submitted to the City in the spring, with no response by the end of the fiscal year.

Another time-consuming episode of the past year involved the Adams-Nervine property. These eight acres, with seven buildings, jut into the Arboretum property and form part of the boundary between the Administration Building-Greenhouse area and Centre Street. The Adams-Nervine property was no longer needed by the Faulkner Hospital and was placed on the real estate market. Acquisition of the land by the Arboretum would have permitted expansion of our collections on contiguous land; the development of special collections; the possibility of a new entrance, of parking, of a reception center, of dormitory space for student employees, and even public toilets. Ac-

cordingly, permission was obtained from the President and Fellows, and a bid was submitted and accepted by the Adams-Nervine trustees. The proposal had to be withdrawn on the day the agreement was to be signed when the Boston Landmarks Commission designated the property, including the buildings, an Historical Landmark. The Arboretum would have demolished many, if not all but one of the buildings on the site. The Landmark designation required the preservation of all of the buildings and would have prevented clearing any land for expansion of the Arboretum collections. Many hearings and appeals were involved. The Arboretum acquired the support of the local residents through the Jamaica Hills Association but was opposed by the Boston Redevelopment Authority, the Landmarks Commission, and many of the local political officers. Subsequently, the Mayor signed a "temporary designation," and a bid was accepted by the Adams trustees from a developer who agreed to create taxable condominiums within the large buildings. We shall watch with interest the duration of the "temporary designation" and the alteration of zoning regulations on the property. We regret that neither the Mayor nor the Park Department felt able to support our desire for this property as an addition to the Arnold Arboretum.

The extremes of weather that Boston can experience were well exemplified during the year. The four months, October through January, proved to be the coldest Boston has endured since 1918. The January temperature averaged officially 23.3° F with a high of 47° and a low of 3° at the airport, but was below 10° on fourteen evenings and reached 20° only one night during the month. On January 7 Boston attained an official reading of 13.8 inches of snow and the Arboretum in Jamaica Plain had over 15 inches, the most snow for one January day since 1897. March and April proved to be warmer than normal, and by April 21 the plants were two weeks ahead of schedule. April rains in excess of normal caused flooding on the grounds due to blocked drains. On May 9 the only measurable snow ever recorded in eastern Massachusetts for May caused great damage in Weston but none in Jamaica Plain. A total of 11 inches of wet, heavy snow was recorded at the Case Estates, with the plants in full leaf and in flower. The remainder of May and the month of June proved to be exceedingly dry and we were plagued with fires on the grounds. The grounds crew and the pruner were extremely busy following each storm, for plants were broken and twisted, requiring much repair work. Electric power was lost in both storms, although the use of emergency generators saved the greenhouse collections in both Jamaica Plain and Weston.

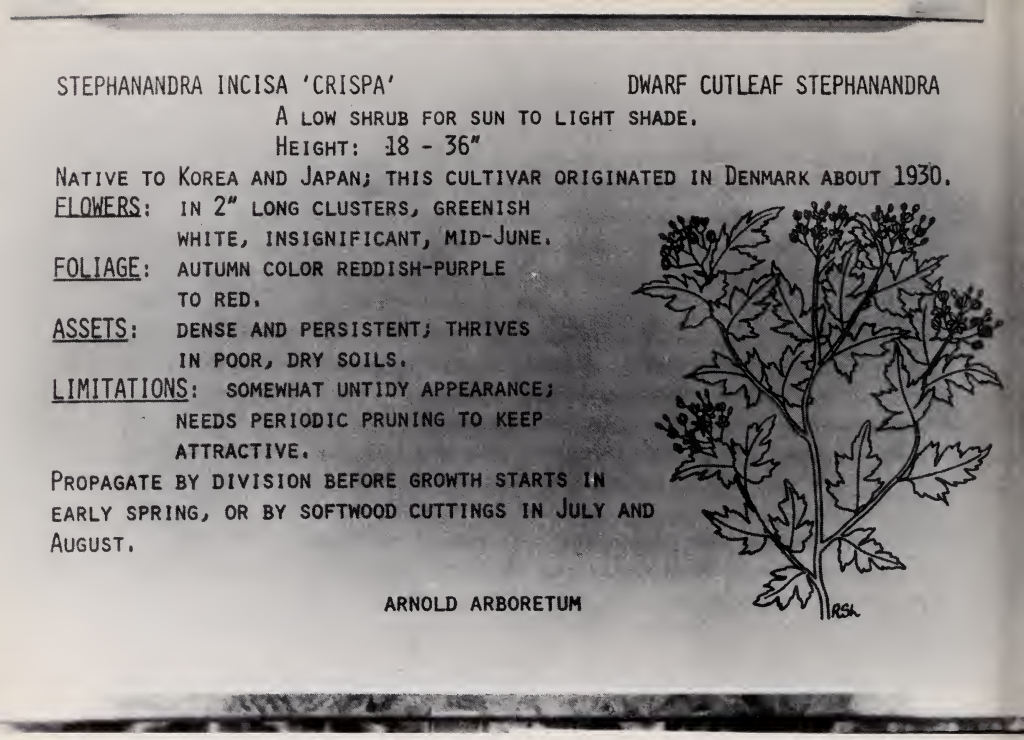
The foul winter weather did permit indoor work, and the lecture room and the lunchroom in the Administration Building in Jamaica Plain were redecorated. New display panels were installed in the lecture room to permit larger exhibitions, and a new storage cabinet for folding tables and screen was built in a stairwell. During May

the roof of the cold storage unit was resurfaced, and the heating-cooling system replaced.

Following the storms, the living collections were reexamined carefully. As a result, a number of damaged or deteriorating plants, weed trees, and duplicated plants were identified. Many have been removed and others will be. One-of-a-kind plants and those representing living types were selected for propagation to place an additional example on the grounds or for distribution to other institutions. The nursery inventory had also increased during the past few years, and a careful survey of our needs revealed that about half of the accessions were already on the grounds or were unneeded. All surplus plants are offered first to the University. Large numbers were accepted by the College, through the office of the Landscape Architect, and by the Business School; the remainder were then offered to other arboreta and botanical gardens and to local colleges or towns, including Cambridge and Weston. The final disposition of surplus plants was made to the Friends of the Arnold Arboretum.

Several generic collections in Jamaica Plain and Weston received special attention in association with taxonomic work of the staff. The entire *Philadelphus* collection was repropagated during the summer of 1976; when the plants are large enough, they will be used to replace the existing collection which lacks vigor and is not visually attractive. The birch collection was checked for identification, for representation in our herbarium, and for evidence of infestation by the bronze birch borer. This insect is among the most serious pests now in the Boston area, and there is a question whether plants in any area of the grounds can be protected against infestation.

Every plant placed in the collections in either the spring or fall planting program must be recorded, not only in the inventory maintained locally, but in the records of the Plant Sciences Data Center. Maps are annotated regularly and redrawn at intervals. Several types of new labels are being developed, and some are being tried experimentally on the grounds. Color-coded, embossed labels, larger than those used previously, are being provided for staff use and visitor reaction. Plants introduced by the Arnold Arboretum bear an orange label. Deciduous plants are marked in yellow, and evergreens in red. Plants representing living type specimens have blue labels. An information kiosk is planned to explain the coding of the labels, refer to outstanding floral areas or plants, and display a map of the grounds as well as the rules and regulations. Larger labels, stressing uses, culture and propagation, and origin or availability, are being placed in the ground cover plots at the Case Estates, and some will be placed in Jamaica Plain to determine visitor reaction. A "strip printer" was purchased and labels are being prepared on "Scotch-cal" to obtain a negative that will permit ready and replicated reproduction on "Foto-foil."



One of the new, informative plant labels on trial in Jamaica Plain. Photo: P. Chvany.

In response to requests for plant materials for growth or for experimental projects, 130 shipments were made representing 630 taxa, and 54 shipments of seeds of 160 taxa. Most requests came from the United States, but some also from fifteen other countries in North America, Europe, Asia, and the West Indies. Two hundred nine taxa were propagated to prepare replacements for specimens that appeared to be failing or were represented by insufficient numbers in the collections.

At the request of the office of the Landscape Architect, a section of land on the Case Estates has been designated for the use of that department to grow selected plants for University use. Many desirable landscape plant materials are not available in quantity from our surplus plants or in large size from commercial sources. The land chosen will be used to set out smaller plants and give them sufficient time to develop larger stature, to be available when needed. Dr. Weaver completed a project of identification and mapping of all the plants on the grounds of the Harvard Business School. The greenhouse staff propagated mulberry seedlings to be held in our greenhouses for a silkworm research project of the Harvard Medical School. The greenhouses are also used to aid graduate student research, and materials in the programs of seven graduate students are being cared for.

In cooperation with the City of Boston, a portion of the South Street tract of Arboretum land is being studied for the establishment of neighborhood vegetable gardens on a temporary basis. The land involved cannot be developed for the Arboretum collections until the final plans are made for the relocation of the Orange line and the Forest Hills rapid transit system operations of the Massachusetts Bay Transit Authority. The line's relocation and the associated highway development will alter the drainage and the boundaries of the property. The temporary use for "victory gardens" can be implemented, provided the City will install pipes and supply water.

The staff also is developing plans for a walk to be constructed on top of a storm conduit through the meadow near the Administration Building. Such a walk through a marsh-swamp area would offer convenient observation of the swamp plants and the wild life that abounds in the area. The actual installation of the walk will require permission of the City of Boston, and it is hoped this can be acquired in the fall to permit completion during the winter when the ground is frozen.

In association with their professional work, three staff members attended a University of Massachusetts Extension Service meeting on labor-saving devices; three attended a Management Workshop Series offered by Harvard's Career and Organizational Development Training Center; and six attended a series of meetings on pesticides and plant nutrition sponsored by the Massachusetts Nurserymen's Association.

The Arnold Arboretum serves as the International Registration Authority for specific groups of cultivars, and as the National Registration Authority for woody plants not otherwise represented by registration appointees. Dr. Spongberg is chairman of the American Association of Botanical Gardens and Arboreta plant nomenclature and registration committee, and of the comparable committee for the American Horticultural Society. A two-day conference was sponsored by the Arnold Arboretum for those persons involved in such activities. Dr. Howard serves on the Plant Sciences Data Center committee of the American Horticultural Society. Records of plants registered are published in the *Bulletin of the American Association of Botanical Gardens and Arboreta.*

A special gift from Mr. Paul Bernat has permitted the development of a plant propagation unit in the cold storage house in the greenhouse area. The experiment is designed to root cuttings under artificial lighting, and with controlled temperature and humidity so that the plants, once rooted, can be held at low temperatures until the weather permits direct transplanting to outside beds. If successful, this project will reduce the intensive labor requirements of hardening off rooted cuttings and several transplanting sequences.

Mrs. Constance Derderian, honorary curator of the bonsai collection, offered several courses in bonsai at the Arboretum greenhouses,

and donated much time to the care of the special plants during the year. In addition, she edited a handbook on bonsai for the Brooklyn Botanic Garden series, *Plants and Gardens*, writing many of the articles herself.

Mr. Peter Chvany was commissioned last year to produce a film for the Arnold Arboretum on the subject of plant propagation. The filming and editing were completed during the year, and the prints for showing should be available in the fall. Mr. Chvany's interest in E. H. Wilson as a photographer led to an issue of *Arnoldia* on the subject, and a special exhibition of Wilson's photographs. The year 1976 marked the hundredth anniversary of Wilson's birth. The work may be continued in the production of a book, and Mr. Chvany is transcribing many of Wilson's field notebooks and diaries and re-examining the photographs and negatives taken in Asia. Regrettably, both Wilson's daughter and son-in-law died during the year, before they could be interviewed in depth on their reminiscences. There is an attempt to establish a Wilson garden in Chipping Campden, England, Wilson's birthplace. The Arboretum is preparing copies of Wilson artifacts for the exhibition there.

Case Estates

An open house was held at the Case Estates on May 8. The grounds and flowering trees were magnificent following the early warm weather, and a large number of visitors enjoyed a perfect day. However, the following day the record-breaking snow storm hit the Case Estates. Forty trees were so badly damaged that they had to be removed from the organized collection. The pruning crew from Jamaica Plain spent the rest of the month in Weston, aiding the Weston staff in the cleanup and repair operation. Damage was most severe in the birch, ash, and maple collections. Trees that were not broken, such as many of the cherries and mountain ash plants, were badly strained and required tying and bracing. Damaged plants in the wooded and less conspicuous areas will be pruned or removed during the coming fall and winter. The staff is to be commended for carrying through the extra labor required to handle the effects of this storm. However, the full year's work program was set back. Plans to reorganize the nursery area had to be postponed, although one additional section of the ground cover plots was removed, the area was lined with boards, and the soil treated for replanting in the fall.

The long-planned work on Wellesley Street was completed by the Town of Weston during the summer of 1976. The Corporation approved the gift to the town of one quarter of an acre total land to permit the straightening of Wellesley Street, improvement in street drainage, and the location of a sidewalk within the boundaries of the Case Estates. Both curves and rises were eliminated in the reconstruction, and the road level raised in other places. The single stone wall, which has been a feature of the boundary of the property along

Wellesley Street, was not moved, but the raising of the road level by a foot or more reduced the optical impression of the size of these boulders; however, the magnificence of these stones can be seen from the Case Estates side. In all, the addition of a safe walkway for visitors is an asset to the property, and flooding has been eliminated from a section of the nursery by the installation of drains.

A new brochure for a self-guiding tour of the Case Estates was prepared and is available to visitors. New labels have been placed on many of the trees and shrubs, and informative signs have been installed on many of the ground cover plots. Several volunteers have undertaken an inventory of the perennial garden area and the preparation of up-to-date maps for the collection. Volunteers also began a study of the flowering times of the plants in this garden.

The small lecture room in the Red School House was used for lectures in the fall and winter class program, and was available for special meetings of several visiting groups as well as for meetings of the American Rock Garden Society, the Rhododendron Society, and the American Hemerocallis Society.

The clonal plantings of the Cabot Foundation in one section of the Case Estates have been maintained for nearly thirty years for the study of growth rates and hardiness in *Populus*, *Quercus*, and *Pinus*. With the death of Mr. Scott Pauley several years ago, and of Dr. Albert Johnson during the year, the responsibility for the continuing observations has been given to Dr. Harrison Flint of Purdue University and Dr. Frank Santamour of the United States National Arboretum. Material is taken on a regular schedule for hardiness testing and other studies. One recent observation is of interest: *Pinus strobus*, the native white pine, is subject to attack by the white pine weevil, which causes shoot dieback and a slow growth. The Balkan pine, *Pinus peuce*, although slower growing, appears to be resistant to the weevil. A hybrid of these two species, produced by Dr. Johnson, has proved to be resistant to the weevil and to have a better growth rate than either of the parents. A new series of resin acids, present in *Pinus peuce* and in the hybrid, have been found through chemical studies. This may be significant in the production of weevil-resistant trees for New England forests as well as for ornamental plantings.

Herbarium

There is little progress to report on the basic problem of cramped quarters and less-than-desirable storage conditions for herbarium specimens in the Harvard University Herbaria building in Cambridge. As reported earlier, the Corporation did approve an addition to the building, and preliminary drawings were made by consulting architects in collaboration with the Planning Office to permit cost estimates and the quest for funding. A descriptive appeal brochure was prepared and an advisory committee appointed. Dr. John Torrey is chairman of the committee, yet full, active support of the Uni-

versity is lacking. No significant progress has been made in acquiring the funds for the building construction.

The curatorial work in the herbarium and library in Cambridge has been supported in part by a grant from the National Science Foundation to the University for the collections of the Arnold Arboretum, Botanical Museum, Farlow Herbarium, and Gray Herbarium. The portion assigned to the Arnold and Gray permits the employment of extra mounters and inserters, the acquisition of some supplies, and retrospective binding and cataloguing in the libraries. At the end of the initial grant, permission was obtained from the National Science Foundation to purchase sixty-one herbarium cases, which were placed in the area formerly devoted to the fern collection before that was relocated. This required a considerable shift in the herbarium with the result that some of the families are now inconveniently out of sequence. Although it has been possible to remove all of the Compositae from cardboard box storage, since this family is particularly susceptible to insect infestation, 2,400 cardboard boxes are still used on tops of cases to store mounted material. The type specimens have now been placed alphabetically by genus at the end of each family. Work continues on dividing overfull folders and replacing worn genus covers throughout the herbarium. With the help supplied through the grant, it has been possible to reorganize and annotate specimens associated with recently published monographs when these specimens had not been studied by the author.

The original curatorial grant expired and an application was prepared for a new grant, which was approved in part. The new grant contains an allotment for the purchase of compactors to be utilized in the addition to the building. However, if the building is not ready for occupancy, the significant grant item may be lost.

The recent acquisition of a Polaroid MP-4 camera and equipment, through a grant from the Tozier Fund, has permitted the staff to photograph type specimens before material is sent on loan, as well as specimens on loan from other institutions. Frequently, photographic information can be supplied in response to requests, thus eliminating the need for shipment of specimens. A large negative file of herbarium specimens maintained in Jamaica Plain has been taken to Cambridge for inclusion in a general file of such material. Over two thousand other negatives have been catalogued and placed in new glassine envelopes.

The herbarium staff has maintained a listing of new genera represented in the herbarium that have been described or brought into current use since the publication of Della Torre and Harms *Genera Siphonogamarum*. Such genera lacking the Della Torre and Harms serial numbering had been placed generally at the beginning of each family. As part of the curatorial work, each genus has been checked in the literature to determine its proper position within the phylogenetic sequence of genera maintained in the herbarium. New family boards have been prepared for many genera, the recent additions

placed in proper sequence, and the data included in a new in-house supplement to Della Torre and Harms for use in the herbaria.

A curatorial inventory was made of the fruit, seed, and cone collections maintained separately from the herbarium but cross-referenced in it. There are at present 13,846 such items in Cambridge, and 3,682 units associated with the herbarium of cultivated plants in Jamaica Plain.

Specimens totaling 9,573 were received as accessions during the year, representing exchange, gift, subsidy, identification, and staff collections. Through mounting and direct insertion, 13,203 specimens were added to the herbarium, bringing the total in the Arnold Arboretum herbarium to 1,068,027 specimens, of which 163,268 are of cultivated plants housed in Jamaica Plain. Specimens distributed to other institutions in an exchange program were 2,790.

The herbarium is used on a daily basis by the staff of systematic botanists comprising the Arnold Arboretum professional staff. Myriad questions are answered directly or the answers sought from the plant material preserved as herbarium specimens. The specimens are fundamental to monographic or floristic studies, as recent publications show. Specimens are borrowed from other herbaria to supplement our own holdings in special studies, and are loaned to other institutions or scientists for study and annotation, and are cited in their publications. Fragments of material may be used or supplied for special studies. One of the most interesting is the recent study of mineral accumulations in leaf tissue by Dr. Robert Brooks of New Zealand. The abundant collections of the Arnold Arboretum from tropical Asia have aided in his study of hyperaccumulation of nickel by plants growing on such deposits in Celebes and the Moluccas. Some plant collections revealing large amounts of nickel have even suggested areas worthy of mineralogical study and possible commercial development.

No record is kept of the daily use of the herbarium or the number of specimens consulted or annotated. The activity of the staff and students, however, is indicated in the incoming and outgoing loans. During the past year, 170 loans were made to 56 different institutions in the United States totaling 13,993 specimens. Loans totaling 8,676 specimens were sent to 37 institutions in 16 countries. At the present time, 94,589 specimens from the Arnold/Gray herbaria are on loan. During the year 200 loans were returned totaling 21,989 specimens. It is this type of activity that merits the support of the curatorial grant from the National Science Foundation. However, the cold, numerical statistics do not express fully the work involved in handling the correspondence; locating, extracting, repairing, fumigating, photographing types, counting, packaging and shipping the specimens; and repeating most of the processes when the material is returned. The manager and the curatorial staff are the devoted and uncredited aides to the scientific work that results from the use of herbarium specimens. Now one more regulation has been added to their obliga-

tions: The adoption by the United States government of the goals of an international program for the conservation of natural resources includes the recognition of threatened and endangered species and the regulation of trade or movement of these species. The list of species so controlled includes many specific plants, those difficult to distinguish from the endangered species, and even such general groups as cycads, cacti and orchids. The regulations apply not only to whole organisms, living or preserved, but to parts as well, and to herbarium specimens. There is a provision for scientific institutions to loan or exchange such material, and application was made on behalf of the Arnold Arboretum for permission to send herbarium specimens from our collections on loan. This, in practice, requires the annotation of all packages with the code designating this permit. Although the Arnold Arboretum now has this permit, it is not yet clear how this affects the field work of botanists who may collect for scientific study such general groups as cacti or orchids. As an example of the lack of clarity of present regulations, Dr. Howard, on a field trip to the West Indies, found a cactus not previously reported on the island of St. Maarten, and a second on the island of Saba. In theory, permission to collect these new records should have been obtained before the field work was started.

Library

All staff positions in the library were reviewed by the Personnel Office during the year, and library assistants were raised to grades 3 and 4. Under the supervision of Mrs. Dickinson, librarian, Mrs. Sheila Geary is in charge of the library in Jamaica Plain; and in Cambridge, Mr. Belson, interlibrary loan assistant, Miss Susan Farwell, bindery assistant, and Miss Sandra McLeod, public services assistant, hold appointments made jointly with the Gray Herbarium.

A library committee of staff members of the Gray Herbarium and the Arnold Arboretum offer advice and guidance. Under discussion at the present time is possible participation in a computer-assisted cataloguing system and conversion of the library to the Library of Congress system of classification. The former would eliminate the present hand-processing system, while the latter will produce cataloguing that conforms to national standards, and will provide such by-products as union and subject lists.

With the aid made possible by the NSF curatorial grant, retrospective cataloguing and revision continued, and old volumes were rebound or restored. Pamphlets of the eighteenth century were removed from old bindings and rebound in cloth with acid-free end papers. All bookplates now used in the library are also printed on acid-free paper.

Work continued in Jamaica Plain, with the help of volunteers, in cleaning and treating the volumes of the library. We are grateful for this contributed help in maintaining the resources of the library.

Grounds crew member Vincent Antonovich and a morning's collection of litter. Photo: M. Reynolds.

During the year 725 volumes were added to the library, received by purchase, in exchange for our publications, for review, or by direct gift. The library now contains 85,829 volumes and pamphlets. Of particular interest was a sizable number of books, pamphlets, and artifacts associated with the work of Charles Sargent, given to the library either outright or on permanent deposit by the Sargent-Murray-Gilman-Hough House of Gloucester, Massachusetts. The Worcester County Horticultural Society presented several original letters of Charles Sargent, while other individuals allowed such letters to be copied. Use of the library in Cambridge can be judged by the number of volumes borrowed from the shelves by staff, students and visitors. This number increased by eight per cent during the year.

Three numbers of the Combined Accessions List, Selected Titles, were prepared during the year for staff information. A new intra-library loan form was developed to improve record keeping of material requested and supplied between the libraries in Cambridge and Jamaica Plain. Among the staff contributions to the development of systems and procedures for managing the collections are: a program to expedite binding of paperbacks, pamphlets and rare books; a system to control the use of unbound or recently received periodicals; reorganization of the Kardex periodical check-in system; and improved interlibrary loan record keeping. For the latter item, 626 total requests were received for interlibrary loan of materials, of which 383 were on standard ILL forms. Although some requests had

to be refused due to the condition of the items, many could be handled by photocopying, and only a few volumes actually were loaned.

The librarian completed work as a member of the Council of Botanical and Horticultural Libraries committee on Union List of Serials. At the annual meeting at the Morton Arboretum, Mrs. Dickinson was a member of a panel discussion on preservation. She also attended the annual meeting of the Guild of Book Workers, the meeting of the American Library Association, and that of the American Society of Indexers. She continues to serve on the Harvard University Library's Committee on Bibliographic Control and Computer Applications.

Miss Farwell was awarded the M.S. degree, completing the requirements at the Simmons College School of Library Science. She and Mrs. Geary attended a workshop sponsored by the New England Technical Services librarians. Miss McLeod and Mrs. Geary attended a workshop on the Conversion of Serial Records, a national project in which Harvard University libraries participate.

The library of the Arnold Arboretum is rich in historical and archival materials which still require a great deal of work in cataloguing and maintenance. A special room is proposed in the herbarium addition for such materials to be assembled. When space is available, grants may be sought to expedite this work. Among the archival material, reference is made to historical letters in response to many requests for information during the year. For example, the Big Horn Commission issued during the year a volume entitled *Rediscovering the Big Horns*, based on rephotographing the scenes taken during the expeditions of John George Jack, dendrologist on the Arboretum staff in 1900. The photographs show the changes between 1900 and 1975, and the archival material in the Arboretum library revealed many of Professor Jack's notes on the vegetation seen in the photographs. In another project Peter Chvany has undertaken a transcription of the field notes and diaries of E. H. Wilson, and a reexamination of the photographs and negatives taken by Wilson in Asia. It is hoped that a biography may be assembled.

Volunteers

The Arnold Arboretum staff is very fortunate to have a group of willing helpers called "Volunteers," who donate their time, effort, and talents to many phases of our operations. They are a diverse group, male and female, young and old, retired or still working for a living, talkative or quiet, single or now alone, and a husband and wife team. Some live nearby, while one is unique in being the wife of a college professor living in Switzerland. When her husband spends several months here each year, our volunteer reports for duty at the Arboretum. Many do report on a regular schedule, and others are available on call. We keep no records of the hours they devote to the Arnold Arboretum, and their real reward seems to be in the satisfaction of being part of this staff. They receive no compensation

other than an occasional surplus plant, but all have our sincere thanks and deep appreciation. They are a real help to the staff and are one of the Arnold Arboretum's assets.

When the volunteers were loosely organized five years ago, an informal lecture series was prepared to introduce them to the nature of the organization and its facilities and resources. They learned more on the job. During the past year another introductory lecture series was held for a new group. Their own interests soon became evident and they found their own place to contribute, although most are willing to do what is asked.

Many groups of visitors come to the Arnold Arboretum and request a guided tour. Volunteers who like to teach and to answer questions have been the guides for groups of school children and visiting garden clubs. They have been so effective that one has been requested by name as a guide on a subsequent visit. Several have assisted in staff-taught courses or have offered those of their own. Volunteers have helped staff the building on weekends during the spring; are present when the greenhouse area is open; or are on the grounds during open house occasions or visits by conventions. Their help was invaluable in gathering data for the visitor questionnaire previously mentioned.

One volunteer assembles the most interesting plants on the grounds into seasonal arrangements, properly labeled, in the entrance to the Administration Building. Information tables at flower shows have been staffed by volunteers who answer questions about the exhibit or the Arnold Arboretum. In fact, these are usually the people who helped prepare and stage the exhibit.

One of the outstanding exhibits on permanent display in the Administration Building, a collection of flowers, fruits, and cones embedded in clear plastic, is the work of a volunteer. This exhibit attracts so many questions that she prepared an article on the technique for *Arnoldia*. This volunteer also is implementing a suggestion that the Arboretum have traveling exhibits for school libraries or bank windows.

The greenhouse is an area popular with volunteers, and their efforts are diverse. They collect seeds and propagating material on the grounds to help fill requests or for research needs. They clean the seeds, keep records, and do germination experiments. They weed, take inventories, package plants for mailing, including the massive distribution of small plants to the Friends. They spray rabbit repellent, tie up plants for the winter, record flowering and fruiting times, inspect for disease, and check labels. They pot plants, transplant seedlings, and prepare grafts and rooted cuttings. The greenhouses are open to the public one afternoon a week, and volunteers offer this tour.

Volunteers have helped with the mapping of the grounds, even with the aid of snowshoes and skis in midwinter. One has a special

interest in the conifer collection, which extended to putting a large herbarium collection of cones into proper order, and is now preparing an article on the conifers. He also compiles the annual *Arnoldia* index.

The herbarium has a few devotees among the volunteers. Sorting and inserting herbarium specimens does not appeal to all, but when it does we have an excellent assistant. Others go on the grounds to collect herbarium specimens for addition to our collection or for distribution to other institutions. They prefer to be out of doors, and specimens are collected from plants in flower, in fruit, and in winter condition on a regular basis.

In the library two volunteers have devoted many hours to restoration activities. They received special instruction from the University Library's consultant on conservation, and have systematically dusted, cleaned, and oiled leather-bound volumes. Volunteers have helped prepare shelf lists, alphabetized and located folio volumes, devoted their linguistic talents to translations of titles or articles, relabeled and helped shelve volumes, and are now preparing many of the reviews published in *Arnoldia*. The collection of kodachrome slides has been reorganized by the volunteers who keep up with the additions; one volunteer attended a seminar on the care and preservation of slide collections, sponsored by the Rocky Knoll Nature Center, to compare our procedures with those of others. The scrapbooks of clippings relating to the Arboretum are in excellent shape and up to date through volunteer help.

Last but not least, some volunteers type, and complete clerical work and stuff envelopes. All of these many services are valued and contribute to the efficiency and effectiveness of the staff and the Arnold Arboretum.

Education

The role of the Arnold Arboretum as an educational organization is expressed in many ways, ranging from an active teaching role within the University to the passive role played by the labeled collections or the several publications. Formal courses were offered in the Department of Biology by Dr. Howard (Biology 209, The Phylogeny of the Flowering Plants) and Dr. Wood (Biology 103, The Taxonomy of Vascular Plants); while Drs. Miller and Wood each had a series of lectures in Biology 18 (Diversity in the Plant Kingdom). Drs. Howard, Miller, Stevens, and Wood were guest lecturers in other courses in the Department of Biology, in the School of Design, in Seminar series, and in the graduate student-organized "Society for Expeditionary Biology." Drs. Robertson and Wood both lectured in the special seminar series sponsored by the Harvard Summer School, and Dr. Howard taught a portion of the Summer School course, Plants of The Tropics (Biology S–105), offered in Miami, Florida. Each staff member with an academic appointment offers a numbered research course in the 300 series, which represents individual instruc-

Richard Stomberg, third-year horticultural trainee, at work in saran house. Photo: M. Reynolds.

tion at the graduate level. Staff members also served as undergraduate advisors for the Department of Biology in the College. Weekly seminars are held in Cambridge, and were arranged during the year by Dr. Stevens. Informal horticultural seminars for the staff have been initiated in Jamaica Plain.

A formal course entitled "Botanical and Horticultural Practices at Arboreta" was offered for the first time in 1977 as part of the Harvard University Extension program. Drs. Spongberg and Weaver organized the course, which included lectures, field trips, laboratory sessions, and individual projects under the guidance of a staff member, in addition to assigned work on the grounds. The course allowed the students selected for summer employment to earn four hours of academic credit. One day a week was devoted largely to lectures, laboratory sessions, and field trips. The students were graded not only on their work on the grounds but also on the oral presentation and written reports of their projects. Lectures were given by staff members Alexander, Geary, Howard, Koller, Lynch, Pride, Spongberg, Wadleigh, and Weaver, and by an occasional outside speaker. The summer employees represented thirteen colleges, and the group included two work-study students.

Some New England colleges conduct a "Jan-plan" program, wherein students are required to participate in a professional organization during the month of January vacation. Other colleges use a "student intern" program in which a semester or one day a week are devoted to learning about a profession. The Arboretum staff agreed to accept students in these programs from Connecticut College, Colby College, Pine Manor Junior College, the University of Massachusetts, and the Buckingham-Browne and Nichols School. Depending on the length of time available, the students were assigned to one or more areas of Arboretum activities. At the request of the Cambridge Economic Opportunity Committee, two individuals reported for work-training at the Arboretum for a short period of time. Neither proved to be interested in horticultural work.

Many horticulture classes from other colleges come to the Arnold Arboretum on prearranged visits. A staff member offers a tour of the facilities and the grounds. Many of these groups are interested in career opportunities, while others are concerned with operations or with the plant material. During the year requests for one to three such visits were received from the Universities of Vermont, Connecticut, Massachusetts, New Hampshire, and Maine, Springfield Technical College, Veterans Administration Hospital Horticultural Therapy program, Thompson School, Smith College, Essex County Agricultural and Technical Institute, Minuteman Regional Vocational Technical School, Ontario-Niagara Agricultural and Technical College, five high schools in Massachusetts, and the students of Longwood Gardens. When Boston is the location of a national meeting, many organizations now include a tour of the Arnold Arboretum in their programs. The volunteers may serve as guides for some tours, but the staff will meet other groups such as the American Nurseryman's Association, the Landscape Design Critics Council of the Garden Club of America, the Parks and Recreation Congress, and the Bristol and Norfolk County Tree Wardens, where the interest is professional rather than tourist. The Harvard Club schedules an annual visit to the Arboretum, and Innings and Outings, a newly formed group of Harvard employees, offered trips to Jamaica Plain and to Weston. The Arboretum is listed among the places to visit during Commencement week, and special tours are arranged for the alumni who attend.

The Arnold Arboretum occupies a conspicuous place in Jamaica Plain and in Weston. The staff attempts to cooperate with local groups in supplying speakers, advice, tours, or surplus plants. Open house occasions are scheduled each spring, with the staff on the grounds to answer questions. We have had direct contact with citizen groups in Jamaica Plain, West Roxbury, Roxbury, Roslindale, Cambridge, and Weston. Dr. Shiu-Ying Hu has been active in bringing groups from the Chinese community to the Arboretum. Mr. Robert G. Williams served as a judge at the Massachusetts science fairs, and Mr. Pride at the 4–H horticultural competition in Franklin Park. Each

year the Arboretum donates a dozen or more plants of special interest and value for the fund-raising auction of WGBH Channel 2 TV, the educational channel in Boston. Dr. Howard has served as an auctioneer for several years, and staff member Mr. James Burrows and volunteer Mrs. Elinore Trowbridge manned the telephones on a horticultural hotline.

The Arboretum staff answer telephone calls on a twenty-four-hour basis relating to possibly poisonous plants. Calls are referred to the Arboretum office in the daytime by the Boston Poison Information Center, and to individual staff members at their homes in the evenings. Mr. Pride gave a recorded telephone interview for a local radio station, regarding poisonous plants, which was used in segments over a period of several weeks. The Arboretum film, *Poisonous Plants*, is used frequently in staff lectures and is available from several film libraries or from the commercial distributor. The film was reviewed very favorably in the American Association for the Advancement of Science film review issue, and has had special publicity in a booklet issued by the distributor of the film. Miss Reynolds appeared on the TV show, "Woman 76," talking about poisonous plants, and later on the show, "Place," spoke about the Arboretum.

A cooperative educational program continues with the Massachusetts Horticultural Society. A series of tours called ArboRambles is conducted jointly at the Arboretum. The Arboretum staff have also participated in a lecture series held at Horticultural Hall, and staged an exhibition there of the photography of E. H. Wilson. Joint horticultural workshops involved greenhouse gardening, and techniques of bonsai. The Arboretum staff helped stage a midwinter Orchid and Camellia Show, while the Arboretum exhibit at the Spring Flower Show displayed a map of the world with cultivated ornamental plants in their area of origin. Volunteers at the Arboretum not only helped assemble and label the exhibit, but were present during show hours to answer questions. The exhibit was awarded a first prize, an educational merit certificate, a gold medal, and the coveted Bulkeley Award for educational excellence. Another exhibit, at the Christmas Show held in Horticultural Hall, was also prepared jointly by staff and volunteers and manned during show hours. That also received a first prize.

Four exhibitions were held in the lecture room of the Administration Building of the Arnold Arboretum in Jamaica Plain. "Wilson as a Photographer" was prepared by Mr. Chvany. "Bark is Beautiful" featured the color photography of Mr. Albert Bussewitz. "Flowers — Art or Science?" displayed the paintings of Mrs. Eudoxia Woodward; and the final staff exhibit was on "Poisonous Plants." Each exhibit was preceded by a special open house, a reception, and a lecture.

During the spring and the fall, the Arboretum staff offer a series of courses open to the Friends and the general public. Thirty-nine courses, ranging from one two-hour session to five weekly meetings

of varying duration, totaled three hundred hours of instruction. The smallest class was limited to five students; and the lecture series in Weston, to forty-five. Field walks were limited and had an enrollment of sixty people. The average class had twenty-five participants. Radio and press coverage of the course openings has been good. An attractive brochure with a new format on colored paper is eligible for the educational institution mailing rate, and so has been distributed at a much more reasonable rate than was previously possible.

Two special seminars were organized by the staff during the year. Mr. Koller arranged a program entitled "Interpretation — What Do We Have to Offer," with speakers, Koller for the Arnold Arboretum, Mr. Charles E. Roth of the Massachusetts Audubon Society, Dr. Darrell Apps of Longwood Gardens, and Mr. Bruce McHenry of the National Park Service. Those attending represented thirty organizations from five states. Dr. Spongberg organized a two-day discussion for a group of invited participants on the subject of registration and nomenclature of cultivars. The meetings were held in Jamaica Plain and in Cambridge on successive days.

Travel and Exploration

The Arnold Arboretum is an institutional member of several national and international societies; staff members may be individual members of professional societies, serve on committees, or present papers that require their presence at annual or regional meetings. It is well for the Arnold Arboretum to be represented, and profitable for the individual to participate. Accordingly, partial financial support for attendance is shared among the members of the staff. Vacations for staff members are also apt to be "busman's holidays," for invariably the meeting provides the opportunity to collect specimens for research programs or for addition to our herbarium; to visit herbaria or libraries; or to take photographs that can be used in teaching or lecture programs, or be added to our slide collection. Visits to herbaria or other botanical gardens yield information of value to our organization, and permit the exchange or acquisition of material, and further staff research.

Mr. John Alexander is on the Board of Directors of the International Lilac Society, and attended the annual meeting as well as a preparatory meeting in Amherst, Massachusetts. He was a participant at the annual meeting of the International Plant Propagators Society, and attended the regional meeting of the American Association of Botanical Gardens and Arboreta at the Old Westbury Gardens on Long Island, New York.

Mr. Burrows visited the Brooklyn Botanic Garden.

Mr. Fordham spoke on propagation of the Hamamelidaceae at the International Plant Propagators meeting in New Jersey, and participated in the Connecticut Nurseryman's Education Program in Connecticut.

Dr. Howard conducted field work related to his research on the Lesser Antilles in visits to Barbados, St. Vincent, and Grenada, and collected specimens. As a member of the Scientific Advisory Board of the Arbor Fund, he attended a meeting at the Bloedel Reserve in Washington, en route visiting the Denver Botanic Garden, the University of Washington Arboretum, the Pack Forest, and the University of British Columbia Botanical Garden. Dr. Howard represented the Arnold Arboretum at the dedication of the bonsai pavilion and collection at the United States National Arboretum, and spent time during this trip at the National Herbarium in Washington, D.C. He was the principal speaker at the dedication of the Mini-Arboretum of the City of Portland, Maine, established by the Longfellow Garden Club.

Dr. Hu has published two papers on the medicinally useful plant, ginseng. There is a recurrence of medical interest in this plant for its reputed value in the revitalization of elderly people and those under physical stress. She was invited to attend and speak at an International Gerontological Symposium held in Singapore, and en route visited gardens in Istanbul, Tehran, Bangkok, Sri Lanka, and India. At several herbaria she was able to renew her work on collections of *Ilex*. Later in the spring she spoke about ginseng at the National Institutes of Health in Bethesda, Maryland, and also presented a seminar at the University of Maryland.

Mr. Koller represented the Arboretum and spoke at the annual meeting of the AABGA held at the Missouri Botanical Garden, and at regional meetings at Old Westbury Garden and at the Frelinghuysen Arboretum. While on vacation he examined the collections of the Royal Botanic Gardens at Kew and at Edinburgh, and visited Hillier's Nursery in Winchester, England.

Miss Donna Lynch visited the Brooklyn Botanic Garden, the Morris Arboretum, the Longwood Gardens, the U. S. National Arboretum, and the facilities of the American Horticultural Society and the Plant Sciences Data Center in Mount Vernon, Virginia.

Dr. Miller worked on moss collections at the Natural History Museum in Ottawa, Ontario.

Miss Reynolds represented the Arboretum at the AABGA symposium, "Facing the Future," held at the Callaway Gardens, Pine Mountain, Georgia.

Dr. Robertson paid visits to the U. S. National Arboretum, the Biltmore Estates, and the Memphis Botanic Garden.

Dr. Spongberg reported on plant registration activities at the AABGA annual meeting in St. Louis. He also visited the U. S. National Arboretum when he was in Washington, D.C., as a speaker at the annual meeting of the American Magnolia Society.

Dr. Stevens spoke to the staff of the New York Botanical Garden of his work on the evolution of tropical Ericaceae, and to the Massachusetts Rhododendron Society on Malesian Rhododendrons.

Drs. Weaver and Spongberg are planning a collecting trip to Japan

and Korea in the fall of 1977, and consulted with Dr. John Creech, of the National Arboretum, regarding his recent experiences in the area.

Gifts and Grants

The Arboretum and its staff have been fortunate in the support offered in the form of gifts, grants, and materials from many individuals and sources. The Friends of the Arnold Arboretum respond to annual requests that they renew their membership contributions, and the staff is grateful for this continuing support. Such funds are without restrictions. Although most are used in the work associated with the living collections, some have been used in the production of an educational film on plant propagation; and during the present year, in the support of field work in Japan and Korea for additions to our living collections. A special gift was received from Mr. Paul Bernat for experimental work in plant propagation. A grant from the Stanley Smith Horticultural Trust enables artistic work associated with Dr. Spongberg's work on a manual of cultivated trees and shrubs. A grant from The Charles E. Merrill Trust was specified for the publication of Dr. Howard's *Flora of the Lesser Antilles*, Dr. Perry's treatment of the medicinal plants of Asia, and work on the manual of cultivated trees and shrubs.

Memorial gifts were received in memory of Mr. Thomas Matthews and Mrs. Allen Brailey. Mrs. Katharine Abbott Batchelder died on January 11, 1977. Mrs. Batchelder was, for many years, a member of the Committee to Visit the Arnold Arboretum. She supported, anonymously at her request, work on the taxonomy of cultivated trees and shrubs, and continued this support by a bequest. The obituary notice requested gifts to the Arnold Arboretum in her name, and thirty-four gifts were received.

Artifacts associated with the history of the Arnold Arboretum are always welcome. Special gifts of publications of Charles Sargent were received from the Sargent-Murray-Gilman-Hough House; papers of James Arnold, from Mrs. Charles Jackson, Jr.; letters of E. H. Wilson, from the Worcester County Horticultural Society. Gifts of books for the library were donated by Messrs. Fred Bonnie, Richard J. Eaton, Augustus Kelley, George Taloumis, Mrs. Derderian, and the Botanical Museum, Hunt Institute for Botanical Documentation, the Pennsylvania Horticultural Society, and the Wing Lung Bank. Several other donors wished to be anonymous.

We are grateful for gifts of plant materials from firms including Hillier and Sons Nurseries, Monrovia Nursery Company, Princeton Nurseries, and the Weston Nurseries.

The grant from the National Science Foundation, shared with other botanical collections at Harvard, is truly significant in the curatorial work in the library and herbarium. A grant for an additional three years was received during the year.

Publications

The two regular publications of the Arnold Arboretum are the *Journal of the Arnold Arboretum*, issued quarterly, and *Arnoldia*, issued six times a year. The four issues of the *Journal* published during the fiscal year comprised 523 pages and twenty-three articles by twenty-six authors. The assistant editor, Mrs. Schmidt, is supervised by Dr. Schubert and assisted by an editorial committee whose members, as well as other staff members, review manuscripts. A new cover, illustrating the cone-like follicetum of *Magnolia tripetala*, drawn by Mrs. Karen Velmure, was adopted for the *Journal*. A set of guidelines for authors was prepared, and this is sent to prospective authors who inquire as to the possibility of publication. A subscription increase to $25.00 a volume was announced for 1978. Dr. Schubert attended a meeting sponsored by the National Science Foundation, concerned with editorial processing centers and the improvement of dissemination of scientific and technical information.

Mrs. Jeanne Wadleigh edited the six issues of *Arnoldia* comprising 320 pages and thirteen articles by fourteen authors. Miss Reynolds was appointed assistant editor of *Arnoldia*; members of the staff supply the majority of articles and assist in proofreading. Issues of *Arnoldia* now regularly contain book reviews written by members of the staff and the Arboretum volunteers. Books received for review are added to the library, and the reviews are published if the volume is considered of interest to the readers of *Arnoldia*. Letters have been received regarding the reviews, many complimentary and some critical of the "honest reviews" and the opinions expressed. Two numbers of *Arnoldia* were regarded as special issues. In a photographic essay, Mr. Chvany considered E. H. Wilson as a photographer. For another issue, Mr. Fordham and Miss Leslie Spraker prepared a "Propagation Manual of Selected Gymnosperms," based on experience in handling these plants at the Arnold Arboretum.

The second volume of the *Flora of the Lesser Antilles* was issued by the Arnold Arboretum. The *Flora* is part of Dr. Howard's research, and the volume on the Pteridophytes was prepared by Mr. George R. Proctor. A grant from The Charles E. Merrill Trust assisted in the publication.

Two publications of the Arnold Arboretum, long out of print, are again available through commercial sources. *Contribution from the Arnold Arboretum* #9, "Species of Tradescantia Indigenous to the United States," by Edgar Anderson and Robert Woodson, is available as a microfilm or a xerographic reprint through University Microfilms of Ann Arbor, Michigan. A *Monograph of Azalea, Rhododendron Subgenus Anthodendron*, by E. H. Wilson and Alfred Rehder, has been reprinted in facsimile by the Theophrastus Publishers, Little Compton, Rhode Island. Otto Koeltz Antiquariat, The Netherlands, received permission to reprint Alfred Rehder's *Bibliography of Cultivated Trees and Shrubs*, a volume also out of print.

Richard A. Howard

Weather Station Data for 1976

	Avg. Max. Temp.*	Avg. Min. Temp.	Avg. Temp.	Extreme Max.	Extreme Min.	Precipitation †	Snowfall
Jan.	33	13	23	54	−8	5.98	12.3
Feb.	44.3	23.3	33.8	65	7	2.68	1
Mar.	49.4	29.8	39.6	73	11	2.9	14.75
Apr.	63.1	41.0	52.05	95	20	2.3	—
May	70.8	48.7	59.75	90	33	2.77	—
June	80	60	70	95	41	.90	—
July	84	61	72.5	95	55	5.3	—
Aug.	82.2	60	71.1	100	43	9.44	— #
Sept.	74.6	50.7	62.65	89	36	1.95	—
Oct.	61	41	51	76	24	4.52	—
Nov.	48	28.6	38.3	65	19	.73	1.5
Dec.	34.6	15.3	24.95	56	0	3.42	20

* Temperature measured in degrees Fahrenheit
† Precipitation measured in inches
# Hurricane Belle — August 10

Average Temperature	49.89°F
Precipitation	42.89"
Snowfall during winter of 1975–76	31.56"
Continuous snowcover December 21, 1975 — February 10, 1976	
Warmest Temperature	100°F on August 23
Coldest Temperature	−8°F on January 23
Date of Last Frost in Spring	April 13
Data of First Frost in Autumn	October 20
*Growing Season	190 days

* Growing Season — The growing season is defined as the number of days between the last day with killing frost in spring and the first day with killing frost in autumn. This time is determined by the last spring and the first fall temperature of 32°F or lower.

Weather Station Data for the First Six Months of 1977

	Avg. Max. Temp.*	Avg. Min. Temp.	Avg. Temp.	Extreme Max.	Extreme Min.	Precipitation †	Snowfall
Jan.	29.8	9.7	19.75	47	−1	5.1	19.4
Feb.	37.6	19.1	28.35	53	5	2.49	9
Mar.	52.9	32.5	42.7	89	19	5.55	10
Apr.	62.5	37.1	49.8	90	22	4.3	trace
May	76.2	48.7	62.45	96	32	3.75	1.0
June	77.6	55.2	66.4	87	43	4.15	—

* Temperature measured in degrees Fahrenheit
† Precipitation measured in inches

Average Temperature	44.9°F
Precipitation	25.34"
Snowfall During Winter of 1976–77	60.9"
Continuous snowcover December 17, 1976 — March 6, 1977	
Warmest Temperature	96° on May 25
Coldest Temperature	−1°F on January 18, 19 and 30
Date of Last Frost in Spring	May 10

James A. Burrows

Staff of the Arnold Arboretum 1976–1977

Richard Alden Howard, Ph.D., Arnold Professor of Botany, Professor of Dendrology and Director

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Donald Wyman, Ph.D., Horticulturist, Emeritus

John Herbert Alexander III, A. of Sci., Plant Propagator
Ida Hay Burch, B.A., Staff Assistant (New title effective March 1, 1977)
James Alvah Burrows, B.S., Assistant Plant Propagator
Michael Anthony Canoso, M.S., Manager of the Systematic Collections *
Kathleen Ann Clagett, M.A., Technical Editor of the Journal of the Arnold Arboretum (Resigned October 15, 1976)
Constance Tortorici Derderian, A.B., Honorary Curator of the Bonsai Collection
Lenore Mikalauskas Dickinson, M.S., Librarian *
Alfred James Fordham, Research Horticulturist (Retired June 30, 1977)
Sheila Connor Geary, B.F.A., Assistant Librarian
Arturo Gómez-Pompa, Dr. Sc., Honorary Research Associate *
Henry Stanton Goodell, Assistant Superintendent
Thomas Matthew Kinahan, Superintendent, Case Estates
Walter Tobey Kittredge, B.S., Curatorial Assistant * (Appointed October 15, 1976)
Gary Lee Koller, M.S., Supervisor of the Living Collections
Donna Anne Lynch, Curatorial Assistant
Norton George Miller, Ph.D., Associate Curator and Associate Professor of Biology *
George Howard Pride, M.A., Associate Horticulturist
Margo Wittland Reynolds, B.A., Staff Assistant
Kenneth Ray Robertson, Ph.D., Assistant Curator (Resigned October 31, 1976)
Elizabeth Belding Schmidt, M.A., Assistant Editor of the Journal of the Arnold Arboretum (Appointed August 23, 1976)
Bernice Giduz Schubert, Ph.D., Curator and Senior Lecturer on Biology
Kenneth Dwight Shaw, B.S., Assistant Supervisor of the Living Collections (Appointed September 1, 1976)
Jackie Marie Smith, M.A., Curatorial Assistant * (Resigned August 31, 1976)
Stephen Alan Spongberg, Ph.D., Horticultural Taxonomist (New title effective July 1, 1976)
Peter Francis Stevens, Ph.D., Assistant Curator and Assistant Professor of Biology (New appointment January 1, 1977)
Karen Stoutsenberger Velmure, B.A., Botanical Illustrator
Jeanne Stockbarger Wadleigh, B.S., Editor of Arnoldia
Richard Edwin Weaver, Jr., Ph.D., Horticultural Taxonomist (New title effective July 1, 1976)
Robert Gerow Williams, B.S., Superintendent
Carroll Emory Wood, Jr., Ph.D., Curator and Professor of Biology

* Appointed jointly with the Gray Herbarium

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Alfred J. Fordham - Portrait of a Plant Propagator

by Margo W. Reynolds

It is, after all, a story of hands. Broad and calloused, they tell of one man's life work, a life well-spent. In their simple roughness they speak with uncommon eloquence of the untold numbers of beginnings that have passed between them. How humbling it is to know that life has been perpetuated — indeed, improved upon — by a mere touch, a laying-on of hands.

Given voice, the stories they might tell! The aristocratic and the common, the difficult and the untested, the foreign and the exotic: few are the plants that have not passed through Al Fordham's hands and have not been nurtured by him in turn.

A portrait of Al Fordham is not merely the portrait of *a* plant propagator; it is a portrait of *the* plant propagator, for Al Fordham is unique. His expertise in woody plant propagation is acknowledged throughout the country and his advice is sought, and much valued, by colleagues, both here and abroad. It would be easy to enumerate Al's professional accomplishments; to recite dates and length of service and papers published. To list his achievements, awards and research interests (which are numerous) would be so simple. They add to the portrait, to be sure, but they do not really illuminate the man. Those who wish the facts of Al Fordham's career can find them elsewhere. This is a portrait of the man.

Ask Al's friends and associates to characterize him in a word or two and they respond immediately, without hesitation. The adjectives differ somewhat but together they form a whole that all would recognize. "Inquisitive" and "curious" are oft repeated, and with good reason. There is nothing that does not arouse Al Fordham's curiosity. For many of us, our childhood sense of wonder remains just that — a fleeting phase of youth when everything is looked upon as new, exciting and oh-so-very-interesting. Al Fordham has never lost that childhood gift. It is what keeps him young and intellectually alive. Because propagation was never merely a "job" to Al, but rather an ongoing intellectual pursuit, his work (and by association, his life) has never become stale and routine. His curiosity has led him to develop numerous research interests. The resultant accomplishments have won him a well-deserved position of eminence in horticultural circles.

Al Fordham's greatest gift to the future will not be found in his writings or in the many plants he has brought to fruition. It will be preserved, instead, in the many young people with whom he has come in contact throughout his career. Some may not realize the full extent of his legacy until their careers are well along. Inevitably, however, all will recognize their enormous debt to the man who not only retained his own unique "sense of wonder" but kindled it in others whose lives touched his. Al delighted in the students who sought his advice and nothing pleased him more than seeing one catch a bit of his fire and go forth with enthusiasm and curiosity to make independent observations.

Al Fordham is ingenious, too. Where a machine for a particular operation didn't exist, he invented it. It was a constant source of amazement to all at the greenhouse to see what Al could do with some scraps of wire, a cast-off nut and bolt and a few assorted parts of other machines. None of his inventions was patented, but that doesn't necessarily mean that Rube Goldberg's reputation is safe!

Efficiency means a great deal to Al Fordham and he admired it and inculcated it in his staff. Two of them tell of being sent out on the grounds to collect seeds, and of being instructed to wear their plastic collecting buckets around their necks. This apparently was to serve two purposes: free both hands for picking, and eliminate the need of an extra motion to toss the seeds into a bucket on the ground.

A later Fordham scheme resulted in an even more efficient operation that eliminated the waste of one hand to hold down a branch while the other picked the seeds. A hook was attched to a rope at one end and thrown up to the branch that was to be bent. When it was sufficiently low, the other end of the rope was made into a loop that was slipped around the picker's foot. Both hands now were free for picking, and Arboretum visitors were able to view a most entertaining little operation.

Al Fordham's sense of humor is legend. Everyone who reminisced about him could call forth at least one occasion when one of Al's practical jokes made life at the Dana greenhouses a little more interesting. Once when Arboretum volunteers were packing small plants into mailing tubes for distribution to the Friends, Al played one of his most famous tricks. Spying one of the tubes, he surreptitiously removed it from the assembly line and substituted his bologna sandwich for the *Maackia amurensis* that should have been inserted. Fortunately, the prank was discovered and the mails (then faster than they are now) were not put to the test.

Al Fordham has given much to the Arnold Arboretum and long will be remembered by all who knew him. Someone once told me that "if it's alive and growing, then Al's interested." How fortunate for all of us.

Preserving Woody Plant Material for Winter Arrangements

by Cora L. Warren

Many excellent books, pamphlets and articles have been written on the subject of preserving flora for winter arrangements, but it is far from an exact science. Only a few of the many hardy woody plants that respond to treatment are mentioned, although there are wide possibilities of achieving interesting and unique effects with such materials.

Branches treated in glycerine, in particular, can add a whole new dimension to the usual dried winter bouquets of grasses, statice and star flowers, or silica-gel dried flower heads, producing beautiful arrangements appropriate to a large variety of settings.

Almost all foliage can be dried by pressing the branches between sheets of newspaper and placing them under a light weight. This method will retain the leaf shape, but the color will be somewhat muted and the leaf will be unnaturally flat and difficult to use in a container.

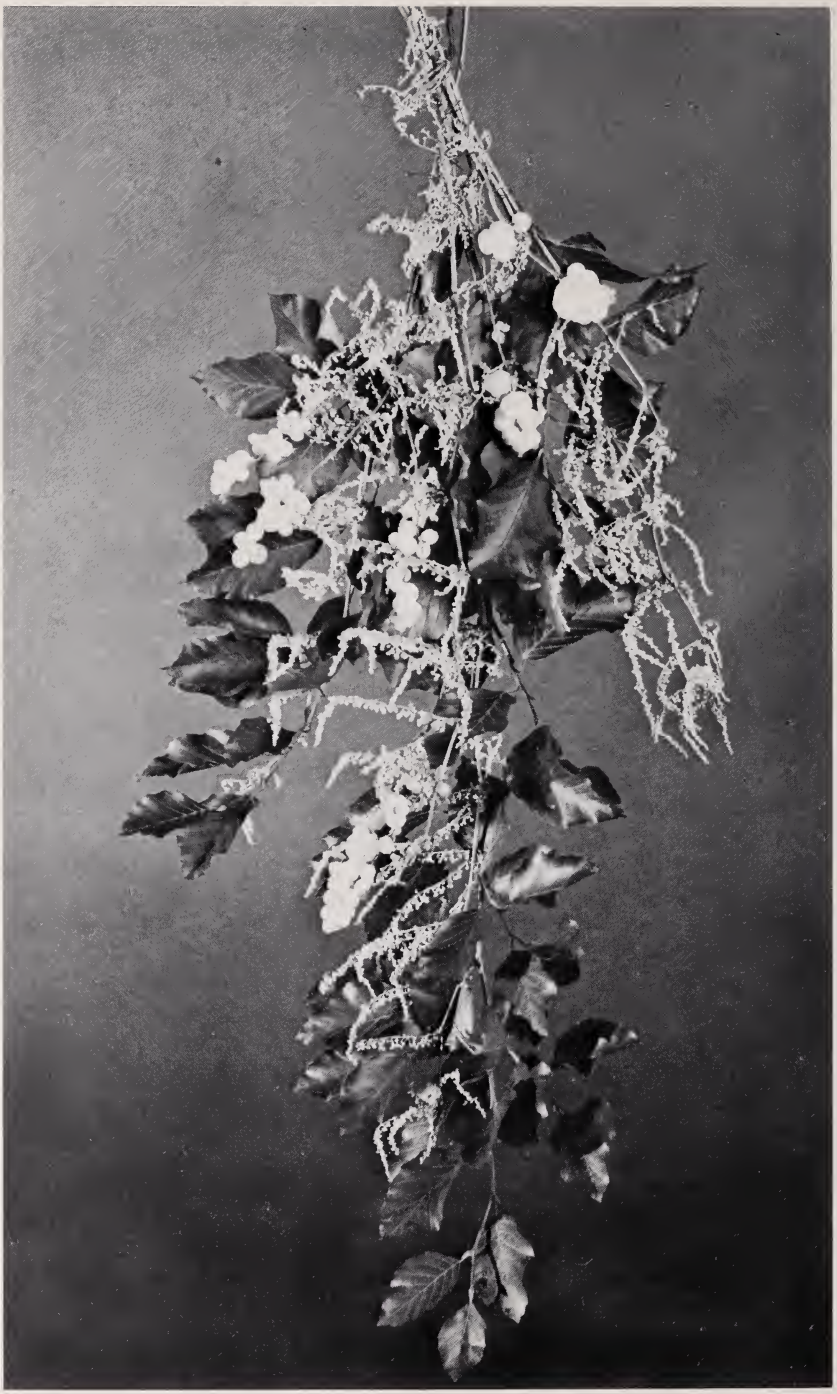
There are some plants that may be air dried and will retain their interest. Hung by their stems in a warm, moisture-free environment until completely dry, they serve as a pretty contrast to the more dramatic glycerine treated material.

Many fruits dry naturally on the plants and need only be collected at the appropriate time. Some of this material becomes very fragile when dry and shatters with too much handling. This difficulty can be prevented to some extent by dipping the fruits after they are dry in a mixture of equal parts of clear lacquer and alcohol, or in an acrylic polymer medium thinned with water.

Most soft fleshy fruits such as berries do not dry well, but the few that do should be defoliated and placed upright in containers, or hung by their stems in a cool, dry place until thoroughly dehydrated. Their staying power can be improved by the use of lacquer and alcohol or acrylic polymer as described above.

Glycerine and water treatment will preserve foliage almost indefinitely, and leaves treated by this method can be used effectively for years. The color of the leaves changes, sometimes dramatically, but the form and texture retain their original aspect.

Cut or crush plant stems and place them in a glass jar containing a mixture of one part glycerine to two parts water. One part anti-



freeze to three parts water can be substituted if glycerine is difficult to obtain. The level of the liquid will drop quickly if large branches are absorbing it successfully, so it is well to check the liquid level daily, and top up with more of the mixture as needed. A tablespoon of charcoal added to the container will stop the formation of a grey film that sometimes appears on the surface. The liquid can be stored and used for another year if it is strained through fine cheesecloth and more charcoal added.

Not all woody plants will take up the glycerine successfully by the method described. Some authorities advise preserving certain materials by total immersion in a bath of glycerine solution; vines and other small plants that otherwise are a failure often respond to this treatment. Broad-leaved evergreens are particularly satisfactory at all seasons, except possibly in the dead of winter, and have the advantage of being available after deciduous trees and shrubs have become dormant.

Branches cut as the season advances toward autumn generally react better to treatment than if gathered earlier, but the conditioning takes somewhat longer as the sap is not flowing as freely.

The number of days taken to complete the absorption of glycerine sufficient for satisfactory preservation will vary greatly. Leaf color will continue to darken after removal from the liquid so a little experimentation may be needed to ascertain when to stop the process. Some books advise waiting until the leaves begin to ooze, but this produces an unattractive and dust-catching surface. A good test is to bend the leaves gently after they have been immersed in the solution for a few days; when they have reached the consistency of soft leather, they are ready for use.

It is well to cut considerably more material than will actually be needed, as the end product will vary from plant to plant, or even from specimen to specimen of the same plant.

Preserved branches may be stored flat in large boxes or hung until needed in a dry, airy place. If the leaves become crushed or limp on removal from storage, they sometimes can be restored by a light pressing with a warm iron, or by placing them between sheets of newspaper under a rug for a few days.

When one is planning a garden or adding to a collection, a new source of pleasure can be achieved by the discriminating choice of plants that lend themselves to preservation; for then, with little effort, the delights of the garden can be enjoyed indoors in a unique and intimate way during the long winter months.

Fagus grandifolia, Oxydendrum arboreum, Symphoricarpos albus. *The white berries of the* Symphoricarpos *are added as a temporary accent though they do not dry well. Photo: P. Chvany.*

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Cora Warren, a volunteer and Friend of the Arnold Arboretum, is responsible for the beautiful seasonal arrangements that regularly appear in the entrance to the Administration Building.

Cryptomeria japonica lobbii, Mahonia *sp.*, Carpinus orientalis. *Photo: P. Chvany.*

A Guide by Plant Family to Foliage Preservation

by Sheila Magullion

A comprehensive list of hardy woody plants that can be preserved by glycerine treatment has long been needed. Therefore, this guide has been compiled after experimentation with a wide range of plant materials drawn from the Arnold Arboretum's collections in Jamaica Plain; all are hardy in the Boston area.

Results of the testing showed that, with few exceptions, all members of a family react in much the same manner. Some families refuse completely to absorb the glycerine mixture; some absorb it, but with poor results; and some are outstanding in their response. Exceptions to the general rule could be vines, which are usually a failure — especially if they are deciduous — and broad-leaved evergreens, which nearly always give excellent results even though they may belong to a mostly deciduous family that otherwise has a poor response to glycerine. Some families may react in a different manner if treated earlier in the year.

The following information has been compiled from experience gained during the months of July to November, inclusive. Genera tested are listed under each family. It was not considered possible to test all species in some of the large genera, such as *Acer* and *Salix*; therefore, in those and similar cases, conclusions were made after trials with half a dozen species. The total immersion method was not used in any case.

In order to keep the guide as concise as possible, the general remarks for the family apply to all members mentioned, unless otherwise stated. Additional information — often relating to the value of the fruits, when and how to dry them — will be found following many listings, and is indicated by an *.

ANACARDIACEAE **Cashew Family**

Glycerine treatment of foliage improves toward the end of the growing season, but results will vary greatly. Fruits require no drying.

* *Cotinus* (smoke bush) — Red-leaved forms of *C. coggygria* are more effective than the green. Large plumy fruit panicles last very well if collected no later than July.

Rhus (sumac) — Large red fruit heads can be useful in large arrangements.

AQUIFOLIACEAE **Holly Family**

Evergreen foliage takes glycerine very well, becoming a dark brown in most cases. Deciduous types are not a success. Fruit is very long lasting.

Ilex (holly), **Nemopanthus*

* *Ilex* — Fruit of *I. pedunculosa* is outstanding. Matures late and can be collected into November. *I. verticillata* and *I. decidua* have profuse fruits that dry well and can be collected into the winter months. The latter is the more desirable.

ARALIACEAE **Ginseng Family**

Handsome foliage takes glycerine but then droops unattractively. Fruit not suitable for drying.

Acanthopanax, *Aralia*, *Hedera* (ivy), *Kalopanax* *

* *Kalopanax* — Huge leaves on long petioles take treatment surprisingly well. Can be treated and used individually.

BERBERIDACEAE **Barberry Family**

Evergreen genera and species have excellent foliage that takes glycerine superbly. The colorful fruits are too fleshy to dry well.

* *Berberis* (barberry) — Contains deciduous species that are much less successful than the evergreens.

Mahonia — Assumes red winter coloring that is particularly attractive after glycerine treatment.

Mahoberberis — Evergreen hybrids between the two preceding genera.

BETULACEAE **Birch Family**

Contains good foliage that refuses treatment early in the year, but by August and September seems to be quite satisfactory. All have interesting fruit clusters that dry easily and last well if collected early.

* *Alnus* (alder) — Dry strobiles like small cones can be collected at any time.

Betula (birch) — Catkins should be collected by midsummer.

Carpinus (hornbeam) — Pendulous clusters of small nutlets enclosed in leafy bracts should be collected during July and August for best results. Can be dried or treated with glycerine for an olive-green effect.

Smilax *sp.*, Rhododendron smirnowi, Cotinus coggygria. *Photo: P. Chvany.*

Corylus (hazelnut) — The attractive nuts are beloved by squirrels and so should be collected green by late July.

BUXACEAE **Box Family**

Evergreen foliage takes glycerine very slowly. Fruit of little interest.

Buxus (boxwood), *Sarcococca*

CALYCANTHACEAE **Calycanthus Family**

Interesting fruit a dry pod somewhat resembling a fig. Sparingly produced but dries well. Foliage a failure.

Calycanthus (sweetshrub)

CAPRIFOLIACEAE **Honeysuckle Family**

Contains many horticulturally popular genera. The foliage takes glycerine but then droops in some cases. Fruits are too soft to dry.

Abelia,* *Diervilla*, *Dipelta*, *Kolkwitzia* (beauty bush),* *Lonicera* (honeysuckle),* *Sambucus* (elderberry),* *Symphoricarpos* (snowberry),* *Viburnum*,* *Weigela*

* *Abelia* — Evergreen species give satisfactory results.

Kolkwitzia — Fuzzy seed heads are moderately attractive but must be collected in July.

Lonicera — Foliage of some of the small-leaved species and forms are very successful.

Sambucus — An exception in that it did not take glycerine.

Symphoricarpos — Foliage responds well.

Viburnum — Evergreen foliage of *V. rhytidophyllum* droops after treatment but is handsome enough to be worth wiring.

CELASTRACEAE **Staff-tree Family**

Foliage takes glycerine but, except for the evergreen members, is not worthwhile. Excellent for fruit.

* *Celastrus* (bittersweet) — Well-known yellow and red capsules should be collected before they split.

Euonymus (spindle tree) — Capsules of various colors must be collected before they split, and treated with alcohol and shellac to help preserve color and prevent dropping. Includes some evergreen species.

Pachistima — Small evergreen foliage takes glycerine well.

Tripterygium — A deciduous vine that does not take glycerine. Long panicles of winged seeds are interesting if collected in August.

CERCIDIPHYLLACEAE **Katsura-tree Family**

Cercidiphyllum (katsura) — Attractive foliage takes glycerine, but not always well. Results from individual specimens vary greatly. Clusters of small pods arranged along the branches are very useful, and can be collected into the winter months.

CHENOPODIACEAE **Goosefoot Family**

Atriplex — Small gray leaves take glycerine.

CLETHRACEAE **White-alder Family**

Clethra (white alder) — Foliage does not absorb glycerine, but the racemes of dry, long lasting capsules are attractive and can be collected into the winter months.

CORNACEAE **Dogwood Family**

An extremely variable family.

* *Cornus* (dogwood) — Results in this genus vary according to species.

Helwingia — This refuses glycerine altogether.

CRUCIFERAE **Mustard Family**

Small evergreen foliage takes glycerine. Fruit is of no interest.

Aethionema, Alyssum, Iberis

CYRILLACEAE **Cyrilla Family**

Cyrilla (leatherwood) — An interesting shrub that responds well to glycerine but the leaf arrangement makes it difficult to use effectively.

ELAEAGNACEAE **Oleaster Family**

Foliage is inclined to droop after treatment, but the silver and grey colors provide such a welcome change from olives and browns that extra fussing is worthwhile. Spectacular fruit is too soft to dry well.

Elaeagnus (oleaster),* *Hippophae* (sea buckthorn), *Shepherdia* (buffaloberry)

* *Elaeagnus* — Offers the best results in the family.

Magnolia tripetala, Liriodendron tulipifera, Koelreuteria paniculata, Staphylea elegans hessei, Carpinus betulus, Aruncus *sp.*, Hydrangea. *Photo: P. Chvany.*

ERICACEAE **Heath Family**

All genera tried, both evergreen and deciduous, take glycerine beautifully. These have very neat foliage that is ideal for small arrangements. Fruits are most often dry capsules of minor interest; some genera have soft fruits that do not dry.

Andromeda (bog rosemary), *Arctostaphylos* (bearberry), *Bruckenthalia* (spike heath), *Calluna* (heather), *Cassiope*, *Chamaedaphne* (false daphne), *Enkianthus*, *Erica* (heath), *Gaultheria*, *Gaylussacia* (huckleberry), *Kalmia* (laurel), *Ledum* (Labrador tea), *Leiophyllum*, *Leucothoe*,* *Lyonia* (fetterbush), *Oxydendrum* (sorrel tree),* *Pieris*, *Rhododendron*,* *Vaccinium*, *Zenobia* (dusty zenobia)*

* *Leucothoe* — Variegated form of *L. fontanesiana* is particularly good.

Oxydendron — Large leaves are very floppy.

Rhododendron — Large-leaved species and forms are inclined to droop.

Zenobia — Has grey foliage and long racemes of grey capsules that are very handsome.

FAGACEAE **Beech Family**

Superb foliage is excellent after glycerine treatment and is well known to arrangers. Interesting fruits dry naturally but should be collected early before the squirrels take them.

* *Castanea* (chestnut) — Large leaves are inclined to flop and may need wiring. Collect the chestnuts in early September.

Fagus (beech) — The many forms of *F. sylvatica* make an interesting change and could be used more often.

Quercus (oak) — Acorns may need a drop of glue to hold them in their cups. Small-leaved species are generally easier to use.

GRAMINEAE **Grass Family**

Not satisfactory in glycerine but the narrow-leaved genera air-dry quite well and the broader leaves can be pressed.

Arundinaria, *Phyllostachys*, *Sasa*, *Sinarundinaria*.

HAMAMELIDACEAE **Witch-hazel Family**

A very satisfactory family that takes glycerine beautifully. Fruit mostly of little interest.

Corylopsis, *Fothergilla*, *Hamamelis* (witch-hazel), *Liquidambar* (sweet gum),* *Parrotia*, *Parrotiopsis*.

* *Liquidambar* — Foliage and fruit is very different from the other members of the family. Long petioles permit the leaves to droop somewhat after treatment. Fruit a prickly globe-shaped collection of capsules popular for Christmas decorations.

HIPPOCASTANACEAE **Horse-chestnut Family**

Aesculus (horse-chestnut) — Foliage does not respond to glycerine. The well-known nuts will need glue to hold them in their cases and should be collected in August.

LABIATAE **Mint Family**

Aromatic foliage and small flowers that are best dried by the hanging method.

Elsholtzia, *Lavandula* (lavender), *Perovskia*, *Salvia* (sage), *Teucrium* (germander), *Thymus* (thyme).

LARDIZABALACEAE **Lardizabala Family**

Foliage takes glycerine but then droops. Large fleshy fruits do not dry well.

Akebia,* *Decaisnea*

* *Akebia* — Deciduous vines that produce usable results late in the season.

LEGUMINOSAE **Pea Family**

A large family that includes many popular members that unfortunately are of little use for drying and preserving. Fruits are a pod interesting only for size in a few genera. Mostly compound foliage either closes up or refuses glycerine.

Albizzia (silk tree), *Amorpha* (false indigo),* *Caragana*, *Cercis* (redbud),* *Cladrastis* (yellow-wood),* *Colutea* (bladder senna),* *Cytisus* (broom), *Genista*, *Gleditsia* (honey-locust),* *Gymnocladus* (Kentucky coffee tree),* *Halimodendron* (salt bush), *Indigofera*, *Laburnum* (golden chain tree), *Lespedeza*, *Maackia*, *Pueraria* (kudzu vine), *Robinia* (false acacia), *Sophora* (Japanese pagoda tree), *Wisteria* *

* *Amorpha* — Fruits are small pods in dense terminal spikes.

Cercis — Simple leaves that sometimes absorb glycerine.

Cladrastis — Does take glycerine but not satisfactorily.

Colutea — Interesting inflated pods.

Gleditsia — Fruit a very large flat, twisted pod.

Gymnocladus — Interesting heavy pods.

Wisteria — Attractive velvety pods that cannot be prevented from splitting.

LEITNERIACEAE **Corkwood Family**

Leitneria (corkwood) — Has good foliage that responds well to glycerine. Fruit a drupe not often produced.

LILIACEAE **Lily Family**

The two hardy woody members are very useful to the arranger.

* *Smilax* (green brier) — Wonderful foliage takes glycerine superbly. Prickles should be snipped off before treatment.

Yucca — Sword-shaped leaves absorb glycerine very slowly and are probably better pressed or air dried. Fruit a cluster of capsules that dry very well. Collect by midsummer.

MAGNOLIACEAE **Magnolia Family**

Has very handsome foliage that does not always absorb glycerine well but is worth perseverance. Large fruits are spectacular but difficult to dry.

* *Liriodendron* — Foliage from young trees seems to respond to treatment better than that from older specimens. The long petioles permit the leaves to flop and will need to be wired, or the leaves can be used individually. Fruit is a pointed cone that dries well but needs shellac treatment to prevent shattering. Collect in August.

Magnolia — Some species have very large leaves that are better used individually. *M. virginiana* is the most satisfactory of the smaller-leaved species. Fruits should be collected as they begin to split, and treated with shellac to hold the seeds in place.

MALVACEAE **Mallow Family**

Hibiscus (shrubby althea or rose of sharon) — Has unremarkable foliage that takes glycerine quite well. Fruits are attractive capsules popular with arrangers.

MYRICACEAE **Sweet Gale Family**

Excellent foliage absorbs glycerine well. Fruit dries readily.

Comptonia (sweet fern), *Myrica* (bayberry)

OLEACEAE **Olive Family**

Foliage takes glycerine well with some variations. Fruit is not exciting.

Abeliophyllum, Chionanthus (fringe tree),* *Fontanesia, Forsythia, Fraxinus,* Ligustrum, Syringa* *

* *Chionanthus* — Foliage is very good. The blue fruits dry well.

Fraxinus — Foliage is a complete failure.

Syringa — Foliage is not very satisfactory.

PINACEAE **Pine Family**

With the exception of the very resinous genera, most members of the Pine Family absorb glycerine well. However some turn a dark brown that is not particularly attractive. Since many last so well untreated, the family is included here primarily for its deciduous members; all have cones invaluable to the arranger.

* *Abies* (fir) — Heavy resin inhibits the absorption of glycerine.

Cedrus (cedar) — Too resinous for success.

Chamaecyparis (false cypress) — Takes glycerine but some species and forms turn brown. Foliage of *C. squarrosa* is interesting after treatment.

Cryptomeria — Turns a dark brown.

Cupressus (cypress) — Takes treatment well.

Juniperus (juniper) — Takes glycerine but also lasts indefinitely without any treatment.

Larix (larch) — Very successful.

Libocedrus (incense cedar) — Takes treatment fairly well.

Metasequoia — Very successful.

Picea (spruce) — Too resinous for success.

Pinus (pine) — Too resinous for success.

Pseudolarix (golden larch) — Young specimens seem to react best.

Pseudotsuga (Douglas-fir) — Too resinous for success.

Sciadopitys (umbrella pine) — Turns an attractive tan color.

Sequoiadendron (redwood) — Very successful.

Taxodium (bald cypress) — Moderately successful.

Thuja (arborvitae) — Very satisfactory in all forms tried.

Thujopsis — Turns a dark brown.

Tsuga (hemlock) — Takes glycerine but drops many needles.

Leucothoe fontianesiana *'Girard's Rainbow'*, Mahonia bealei, Liriodendron tulipifera, Castanea pumila. *Photo: P. Chvany.*

PLATANACEAE **Plane-tree Family**

Platanus (plane tree) — Large foliage takes glycerine particularly well. The spherical seed heads on long pendulous stalks are long lasting if collected no later than August.

RANUNCULACEAE **Buttercup Family**

Foliage absorbs glycerine but droops too much to use. Fruits interesting and useful.

* *Clematis* — Plumy seed heads should be collected as soon as they form.

Paeonia (peony) — Foliage can be pressed or single leaves wired after glycerine treatment. Collect the attractive pods after they open in September.

Xanthorhiza (yellow root) — Fruit too filmy to be effective.

ROSACEAE **Rose Family**

A large, horticulturally important family that gave some of the most outstandingly successful results of any family tested. Foliage of most members quickly turns a very dark reddish-brown. Most of the spectacular fruits are too soft and fleshy to dry well.

Amelanchier (shadbush), *Aronia* (chokeberry),* *Aruncus*,* *Chaenomeles* (Japanese quince), *Cotoneaster*, *Crataegus* (hawthorn),* *Cydonia* (quince), *Exochorda*, *Kerria*, *Malus* (apple), *Neillia*,* *Photinia*,* *Physocarpus* (ninebark),* *Potentilla* (cinquefoil), *Prinsepia*,* *Prunus* (plum, cherry, etc.),* *Pyracantha* (firethorn),* *Pyrus* (pear),* *Rhodotypos*, *Rosa* (rose),* *Sorbaria*,* *Sorbaronia*, *Sorbus*,* *Spiraea*, *Stephanandra* *

* *Aronia* — Some species have fruits that dry well.

Aruncus — Fruit clusters are useful if collected in July.

Crataegus — Among the larger fruits offers the best hope for successful drying. Contains many different species that ripen from July to October. Collect at the first sign of color and hang to dry.

Neillia — Foliage is inclined to droop.

Photinia — Red berries that ripen late and last well treated with alcohol and shellac.

Physocarpus — Heads of dry follicles are of possible use.

Prinsepia — Uncomfortably thorny to work with.

Prunus — *P. laurocerasus* foliage is particulary good.

Pyracantha — Too thorny for comfort.

Pyrus — *P. calleryana* 'Bradford' foliage is outstanding.

Rosa — *R. multiflora* and *R. virginiana* fruits dry and last extremely well.

Sorbaria — Seed follicles in branching clusters that are very useful.

Sorbus — Contains species such as *S. alnifolia* and *S. hostii* with fabulously successful foliage. Fruits of the former and a few others dry well, but most are too soft.

Stephanandra — Small foliage on arching stems is good for small arrangements.

RUBIACEAE **Madder Family**

Cephalanthus (button-bush) — Foliage is successful in glycerine but is not particularly interesting. Seeds arranged in a spherical head.

RUTACEAE **Rue Family**

Foliage refuses glycerine. Some members have attractive fruits that dry well.

*Evodia,** *Orixa, Phellodendron* (cork tree),* *Poncirus* (hardy orange),* *Ptelea,** *Zanthoxyllum*

* *Evodia* — Outstanding large clusters of numerous seed pods should be collected as soon as they mature around mid-September, and treated with alcohol and shellac to prevent seeds from dropping.

Phellodendron — Blue fruits in large bunches shrivel but do dry fairly well.

Poncirus — Small oranges must be collected in July while still green.

Ptelea — Fruits are clusters of round samaras that are interesting, but difficult to use.

SALICACEAE **Willow Family**

Foliage refuses to absorb glycerine. The familiar furry catkins are always popular.

Populus (poplar), *Salix* (willow).

SAPINDACEAE **Soapberry Family**

Foliage refuses glycerine. Fruits dry well.

Koelreuteria (golden raintree),* *Xanthoceras* (shiny yellowhorn)

* *Koelreuteria* — Large panicles of papery pods are good for large arrangements. Collect in August.

SAPOTACEAE **Sapodilla Family**

Bumelia (chittamwood) — Has good foliage that takes glycerine well. Fruit has no interest.

SAXIFRAGACEAE **Saxifrage Family**

Foliage absorbs glycerine but droops too much to use. Fruit is of no interest except in *Hydrangea.*

Deutzia, Hydrangea, Philadelphus* (mock orange),* *Ribes* (flowering currant), *Schizophragma.*

* *Hydrangea* — Contains many species with either white, pink or green sterile flowers that dry naturally on the plant, and are extremely showy and useful.

Philadelphus — Small-leaved species produce usable results.

STAPHYLEACEAE **Bladdernut Family**

Staphylea (bladdernut) — Compound foliage responds well to treatment. The green inflated pods are different and interesting. Collect from July to September.

STYRACEAE **Storax Family**

Foliage does not take glycerine successfully. Fruit attractive but too fragile to be of great value.

* *Halesia* (silverbell) — Fruits are dry, winged drupes that drop from the branches very easily. Treat with alcohol and lacquer.

Pterostyrax — Pendulous panicles of furry drupes shatter quickly. Treatment with alcohol and lacquer helps somewhat.

Styrax (snowbell) — Fruits are small ovoid drupes that dry easily. Collect in July for best results.

SYMPLOCOCEAE **Sweetleaf Family**

Symplocos (sweetleaf) — Foliage takes treatment very well. Fruit dries well and although small is very effective because of the brilliant blue color. Collection time in August is very short.

THEACEAE **Tea Family**

Foliage is not satisfactory after glycerine treatment.

Franklinia, Stewartia *

* *Stewartia* — Fruit a beaked capsule that is attractive in some species.

THYMELAEACEAE **Mezereum Family**
Foliage takes glycerine well in the only species tested.

Daphne, Dircа (leatherwood)

TILIACEAE **Linden Family**

Tilia (linden) — Handsome foliage absorbs glycerine fairly well at some times of the year. Fruits are small nutlets attached to a leafy bract.

TROCHODENDRACEAE **Trochodendron Family**
Two uncommon trees that take glycerine well. Fruits are winged nutlets that are not attractive when dried.

Eucommia, Euptelea

VERBENACEAE **Vervain Family**
Members are inclined to be tender in the Boston area and usually kill to the ground; new growth is too lush and soft to take glycerine. Fruits unusual and useful.

Callicarpa (beautyberry),* *Caryopteris, Clerodendron,** *Vitex*

* *Callicarpa* — Collect the long sprays of small violet berries before frost and lay flat or hang to dry.

Clerodendron — Blue berry-like fruits surrounded by bright red calyx remain attractive when dried. Mature very late in the season.

Following is a list of families and their hardy members that have little or nothing to recommend them for preserving purposes.

ACERACEAE (Maple Family)
Acer (maple)
ACTINIDIACEAE (Actinidia Family)
Actinidia (silver or fleecevine)
ANNONACEAE (Custard-apple Family)
Asimina (pawpaw)
ARISTOLOCHIACEAE (Birthwort Family)
Aristolochia (birthwort)
BIGNONIACEAE (Bignonia Family)
Campsis (trumpet vine), *Catalpa*
BORAGINACEAE (Borage Family)
Ehretia, Lithospermum
EBENACEAE (Ebony Family)
Diospyros (persimmon)
EUPHORBIACEAE (Spurge Family)
Andrachne, Securinega

GINKGOACEAE (Ginkgo Family)
GUTTIFERAE (Garcinia Family)
Hypericum (St. John's-wort)
JUGLANDACEAE (Walnut Family)
Carya, Juglans, Pterocarya
LAURACEAE (Laurel Family)
Lindera (spice bush), *Sassafras*
LOGANIACEAE (Logania Family)
Buddleia (butterfly bush)
MENISPERMACEAE (Moonseed Family)
Menispermum (moonseed)
MORACEAE (Mulberry Family)
Broussonetia (paper mulberry), *Macludrania*, *Cudrania*, *Maclura* (osage orange), *Morus* (mulberry)
NYSSACEAE (Tupelo Family)
Nyssa (tupelo), *Davidia*
POLYGONACEAE (Buckwheat Family)
Polygonum (knotweed)
RHAMNACEAE (Buckthorn Family)
Berchemia, Ceanothus, Hovenia, Rhamnus (buckthorn)
SCROPHULARIACEAE (Figwort Family)
Hebe, Paulownia (empress tree)
SIMAROUBACEAE (Quassia Family)
Ailanthus, Picrasma
SOLANACEAE (Nightshade Family)
Lycium (matrimony vine)
TAXACEAE (Yew Family)
Taxus (yew)
ULMACEAE (Elm Family)
Celtis (hackberry), *Hemiptelea*, *Ulmus* (elm), *Zelkova*
VITACEAE (Grape Family)
Ampelopsis (porcelain vine), *Parthenocissus* (Virginia creeper), *Vitis* (grape vine)

A member of the Friends of the Arnold Arboretum and an active volunteer, Sheila Magullion has collaborated with Cora Warren on the exhibit of holiday arrangements using preserved plant materials, currently on display through December 30 in the lecture room of the Administration Building.

Betula jackii, Rubus *sp.*, Staphylea elegans hessei, Celastrus *sp.*, Castanea pumila, Corylus *sp.*, Aesculus glabra. *Photo: P. Chvany.*

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